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THOUGHTS ON ENGINEERING TRAINING

By BALDWIN M. WOODS

Second Vice-President of the Society

"If it's needed and if it's fair, you will support it." Thus a well-known leader described the American attitude toward sacrifices demanded for the war. This view is held by men in engineering education. They believe that engineering manpower is needed for the armed forces, war production, government operation, teaching and war research.

The reorganization of the War Manpower Commission, with Selective Service an agency responsible to the Commission, promises a strong effort to allocate manpower according to the relative needs. An impartial agency, possessed with the facts, is needed to furnish the answers. The plans will doubtless call for a large percentage of young engineers to serve in the armed forces. This is as it should be. It is the first call. All the other war needs are in a sense services. As such, they must be fully and impartially considered. The armed forces have the responsibility of getting the maximum service from the engineers and from their training. They are not numerous enough to meet the need unless assigned wisely. The Army Plan is expected to care for the supplementary training which adapts the civilian to military duties.

The chief concern of the teacher and engineering educator is for the wise and full use of the trained man. He has seen the competition grow. He knows how indispensable the trained mind and engineering knowledge are in both civil and military activities. He knows that there is no very short road to secure adequate training If production falls, he senses loss of engineers and managers. Hence, his anxiety to secure the balanced distribution of engineers to give the greatest total war effort. He knows the hazards of unwise allocation of this critical material, trained engineers.

There is a hazard in the educator's anxiety. He must offer advice, he must provide training. But the responsibility for the decision is not his. Consequently, he must not be an obstructionist. If from his point of view wrong policy decisions are made, he must carry on under them, ready to aid in correction when the unwisdom is revealed. How fortunate it will be if policies for training and using engineers are wisely and fairly conceived! The need is clear, there is hope for wise policies. Let's support the effort!

OCCUPATIONAL BULLETIN NO. 10

NATIONAL HEADQUARTERS
SELECTIVE SERVICE SYSTEM
21st Street and C Street N.W.
Washington, D. C.

December 14, 1942

OCCUPATIONAL BULLETIN No. 10 (Amended December 14, 1942)
EFFECTIVE: IMMEDIATELY
SUBJECT: SCIENTIFIC AND SPECIALIZED PERSONNEL

1. *Persons qualified*

There are certain persons trained, qualified, or skilled in scientific and specialized fields who, if engaged in the practice of their respective professions, are in a position to perform vital service in activities essential to war production and to the support of the war effort.

2. *Critical occupations*

The War Manpower Commission has certified that in certain scientific and specialized fields there are critical occupations, which, for the proper discharge of the duties involved, require a high degree of training, qualifications, or skill. Attached is a list of "critical occupations" in scientific and specialized fields, divided into two groups: (1) Engineering Fields and (2) Other Scientific Fields.

3. *Consideration of occupational classification*

The War Manpower Commission has certified that there are serious shortages of persons trained, qualified or skilled to engage in these critical occupations. Accordingly, careful consideration for occupational classification should be given to all persons trained, qualified, or skilled in these critical occupations and engaged in activities necessary to war production or essential to the support of the war effort, and to persons in training or preparation therefor.

4. *Deferment of students in training and preparation*

A registrant who is in training and preparation for one of these scientific and specialized fields may be considered for occupational classification as follows:

(*a*) A registrant in training and preparation in one of the Engineering Fields may be considered for occupational classification after completion of his first academic year in a recognized university or college, and thereafter, if he is a full-time student in good standing, if he continues to maintain good standing in such course of study, and if it is certified by the institution that he is competent and that he gives promise of successful completion of such course of study and acquiring the necessary degree of training, qualification, or skill.

(*b*) A registrant in training and preparation in one of the Other Specialized Fields may be considered for occupational classification after he has reached the point in such course of study in a recognized university or college, and thereafter, where there remains not more than two academic years for him to complete such course of scientific and specialized study, if he is a full-time student in good standing, if he continues to maintain good standing in such course of study, and if it is certified by the institution that he is competent and that he gives promise of successful completion of such course of study and acquiring the necessary degree of training, qualification, or skill.

5. *Graduate Students*

A graduate or postgraduate student undertaking further studies in these scientific and specialized fields following completion of his normal undergraduate course of study may be considered for occupational classification if, in addition to pursuing further studies, he is also acting as a graduate assistant in a recognized university or college. A graduate student is a student who in addition to pursuing such further studies is engaged in one of the following:

(*a*) In scientific research certified by a recognized federal agency as related to the war effort; or

(*b*) in classroom or laboratory instruction for not less than twelve hours per week.

6. *Opportunity to engage in profession*

When a registrant has completed his training and preparation in a recognized college or university and has acquired a high degree of training qualification, or skill in one of these scientific and specialized fields, such registrant should then be given the opportunity to become engaged in the practice of his profession in an activity necessary to war production or essential to the support of the war effort. In many instances following graduation from a recognized college or university, a certain period of time will be required in the placing of trained, qualified, or skilled personnel in an essential

activity. When a registrant has been deferred as a necessary man in order to complete his training and preparation, it is only logical that his deferment should continue until he has an opportunity to use his scientific and specialized training to the best interest of the nation. Accordingly, following graduation from a recognized college or university in any of these scientific and specialized fields, a registrant should be considered for further occupational classification for a period of not to exceed 60 days in order that he may have an opportunity to engage in a critical occupation in an activity necessary to war production or essential to the support of the war effort, provided that during such peirod the registrant is making an honest and diligent effort to become so engaged.

7. *Effective period of this bulletin*

This bulletin and attached list amends and supersedes Occupational Bulletin No. 10 of June 18, 1942. (Printed in the September Journal of Engineering Education.) This amendment is effective until July 1, 1943, unless sooner amended. During the effective period of this bulletin the War Manpower Commission is giving further study to the training and preparation and utilization of persons trained in these scientific and specialized fields.

(signed) LEWIS B. HERSHEY,
Director.

CRITICAL OCCUPATIONS

Scientific and Specialized Fields

Engineering Fields

Aeronautical Engineers
Automotive Engineers
Chemical Engineers
Civil Engineers
Electrical Engineers
Heating, Ventilating, Refrigerating, and Air Conditioning Engineers
Industrial Engineers
Marine Engineers
Mechanical Engineers
Mining and Metallurgical Engineers, including Mineral Technologists
Radio Engineers
Safety Engineers
Sanitary Engineers
Transportation Engineers—Air, Highway, Railroad, Water

Other Specialized Fields
Bacteriologists
Chemists
Geophysicists
Mathematicians
Meteorologists
Naval Architects
Physicists, including Astronomers
Psychologists

(*Note:* By this amendment Industrial Engineers, Sanitary Engineers and Bacteriologists have been added. Accountants, Economists, Industrial Managers, Personnel Administrators, and Statisticians have been excluded.)

THE PROFESSION OF ENGINEERING

By IVAN C. CRAWFORD

Dean, College of Engineering, University of Michigan

At the October meeting in Chicago of the Council of S. P. E. E. a proposal was received from the Engineers' Council for Professional Development requesting that our Society appoint a committee to coöperate with the Committee on Professional Recognition of that organization. The Council looked with favor on the proposal and assigned the project to Committee on Personal Development.

The measure on the importance of this subject to the engineering profession can be judged by the amount of space devoted to it in the journals of the Founders' societies and in discussions at their meetings. Hardly an issue comes from the press without a more or less extended article on some phase of the professional status of the engineer. Reverberations of these discussions are reflected in proposals to alter in one way or another engineering curricula and thus in the opinions of the proposers elevate the professional status of the engineer. State registration of engineers also has this latter objective in view.

Undoubtedly a large part of our difficulty arises from the fact that the activities of engineers are spread throughout so many functions that it is difficult to separate the strictly professional ones from others which might not be so designated. The report of the S. P. E. E. Committee on Aims and Scope of Engineering Curricula states the situation in the following sentence: "Since the engineering profession class cannot isolate itself from this complex of men and functions as a well defined cast, it may be said to exist as a vaguely bounded nucleus within a much larger enveloping group which we may call the engineering fraternity."

Quite clearly the present is not a proper time at which to initiate extended studies concerning our educational problems. On the other hand it is evident that we must emphasize, even under existing circumstances, the question of professional recognition and make sure that our students become acquainted with the history, tradition, ethics, and social functions of the engineering profession. As evidence of the interest in the professional aspect of engineering, it should be noted that colleges ordered over 3,000 copies of "The Second Mile" by Dr. Wickenden. In addition,

two of the engineering societies (Chemical and Electrical) have distributed it through regular publications to their students; other societies have purchased 5,000 for student branches. This shows the wide and serious interest in the phases of engineering which supplement the technical,—the social, the ethical, and the professional. The Committee on Aims and Scope of Engineering Curricula recognized these phases when it recommended that humanistic-social studies should be directed toward, among other objectives, the "development of moral, ethical and social concepts essential to a satisfying personal philosophy to a career consistent with the public welfare, and to a sound professional attitude."

The Committee on Personal Development will undertake to study during the coming year the methods employed by the colleges to develop an understanding and interest in those phases of engineering which supplement the technical. Specifically, an attempt will be made to get information concerning (1) the method of presentation of "The Second Mile" to staff and students and the reactions to it; (2) the methods of presenting to students the professional aspects of engineering; (3) and reactions of instructors to the general program.

"*The Place of the Engineer,*" by Professor C. R. Young, of Toronto, President of the Engineering Institute of Canada, is veritably "Something to Think About." Dean I. C. Crawford comments: "ECPD should secure reprints and send it to Deans, or better yet to the Student Counsellors. To me there is much of value in this address."

Reprints from *Civil Engineering,* Dec. 1942, are available at 5 cents each; 2 cents in lots of 10 or more; $1.00 per hundred; from ECPD, 29 West 39th St., New York, N. Y.

Copies of "The Second Mile" are still available at 10 cents each; 5 cents in quantity; $3.00 per hundred.

CHAS. F. SCOTT

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ECONOMICS AS A STUDY FOR CIVIL ENGINEERS

By W. E. HOWLAND

Professor of Sanitary Engineering, Purdue University

Economics has been included in the curriculum of civil engineering for many good and sufficient reasons, but I have chosen to mention only one of them: the planting of doubt in the mind of the student so as to stimulate him to examine the assumptions and conclusions of ordinary thinking about the economic world. Doubting is difficult but when learned early and practiced often it can be mastered. The study of economics should be a discipline in doubting.

I still remember the jolt which I received when I realized, in a course in economics, that free trade was logically sound: free trade, which my father as a good Republican had always condemned. It came over me like a revelation that the principles of Republicanism and of "Sound Business," which I had been taught to revere as a monk reveres his faith, might be wrong—might be even dangerously and harmfully wrong in their effect on the people and on the times. It was, I think, an educational experience of considerable significance to me; the sort of thing that Cardinal Newman has referred to as an awakening of the mind, an enlargement of view, the gaining of a new vantage point from which still larger views are possible. But it was an eminence of doubt and not of faith which I attained.

As children we have had many similar disillusionments. We were told the story of Santa Claus with all of its delightful detail and enchantment and we believed it. And then one day with much pain and shock we learned that it was a myth. That was the beginning of our preparation for an understanding of the world of economics, and of the various theories which have been invented to make our economy seem beneficent or rational or endurable as the need might be. Such experiences, though shocking and painful, must be repeated at intervals in order that we may not be thoroughly undone by the impostors and impostures with which the world abounds.

The race in its childhood received the same sort of instruction. It had been taught that all the answers to all the questions that any decent man should ask were known and were written down in a book or were to be answered by particular persons who were in the

mystical know. *Of course* the earth was stationary and the sun and stars moved about it. All the solid citizens, the bankers and lawyers, and all the Chambers of Commerce believed it. And then a few men like Copernicus and Kepler and Galileo came along and shattered the common sense notions of the authorities, thus suggesting that a widely held theory may be a myth.

Strange, isn't it, that myths are so widely taught and believed and so tenaciously held? "A wonder and yet no wonder," as Stevinus wrote under his proof of the parallelogram of forces. Why the Santa Claus myth? Because the parents want to give the children a happy thought and they want the joy of playing a good-natured trick on them, like Voltaire's priest who said, "You have no idea what fun it is to persuade ten thousand persons of a doctrine that you do not believe yourself." Why the myth of the stationary earth? It persisted partly because of stupidity and of mental laziness, and partly because of vested interests of powerful persons and institutions. Why the myth of the beneficence of laissez faire or rugged individualism? A combination, perhaps, of these and other reasons. The profit myth condones if not compels the tearing down of a good house, even in wartime where houses are urgently needed, the destruction of food when men are hungry, the open air burning of billions of cubic feet of natural gas which can never be replaced: hecatombs and holocausts to gods that love not men. To the high priests of the profit myth will the oracle of time proclaim, "If profit stay the end of man, his end may not be stayed."

The legend of the stork is told because grownups choose to avoid telling a truth which seems to them too crude for tender ears. And so with the legends of economics. The crudity and vulgarity of certain forms of poverty are too unpleasant to contemplate. Let us dismiss the subject with the pleasing myth that persons who prefer decent living conditions may obtain them. Virtue is invariably rewarded. Those who are punished must deserve their fate. The message of the "Book of Job" or of Voltaire's "Candide" or of Steinbeck's "Grapes of Wrath" is lost on minds thus insulated by myth from reality.

When we were children playing with blocks, we used to see how tall and wide and astonishing a structure we could make on the smallest foundation before it fell down. But later we tried to make more graceful structures and when we took them down we did so carefully so as not to injure the blocks. Now a huge economic structure of thought and of institutions has been built as if by children, without plan and on altogether too narrow a foundation. It is topheavy, it is awkward, it is grotesque. Some per-

(*Continued on page 391*)

MATHEMATICS IN AERONAUTICAL TEACHING AND RESEARCH *

By ALEXANDER KLEMIN

Guggenheim Research Professor, School of Aeronautics, College of Engineering, New York University

I. The Teaching of Mathematics in Relation to Aeronautics

As a general rule, the aeronautical engineer finds it sufficient to employ straightforward mathematics, standard calculus, linear differential equations with constant coefficients and the like. Such mathematics are taught and well taught in our colleges of engineering. But with diffidence I venture to say that they are taught as mathematics, as a fine discipline of the mind, without sufficient relationship to practical application.

For example, in the case of a beam subjected to a combined direct compression and side load, we arrive at differential equations for the bending moment which are of the simple and of the classical type of linear differential equations, with constant coefficients previously referred to. All my senior students have encountered these equations at some stage of their studies, yet to most of them the problem comes as a distinct shock. Again all our engineering students have at several stages in their educational careers, encountered imaginary and complex numbers. But when they are asked to apply imaginary and complex numbers in the theory of airfoil forms obtained by conformal transformation, they seem to lack the ability to use the merest elements of the theory of the complex function.

I should like to suggest, again with diffidence, to my colleagues who teach mathematics, that they glance through a book entitled "Calculus for Engineers," by the late Professor Perry of the Royal College of Science in London. Perry taught applied mathematics but was a distinguished electrical engineer. Unorthodox in manner and appearance, he wrote a highly unorthodox book in which he managed to use the calculus as a tool for the solution of problems in heat engineering, in electrical engineering and the like, and what was more, to convince the reader that it was such a tool, and to show immediate and interesting examples of the use of this tool.

* Presented at the 50th annual meeting, S. P. E. E. (Aeronautical), New York City, June 27–29, 1942.

His book did not have the order and symmetry of our classical work on the calculus, but it was a fine example of how mathematics might well be taught to our aeronautical engineers.

II. Mathematics in Aeronautical Research

If, in the teaching of conventional aeronautics, equally conventional mathematics are adequate when properly applied in the aeronautical research, the most advanced mathematics will not suffice.

Without attempting classification, I will cite a few examples where aeronautical problems seem to transcend the limits of mathematical knowledge:

1. *Dynamics of Motion of the Airplane*

In writing down the equations of motion of the airplane, two factors obtrude themselves.

a. The aerodynamic forces vary as the square of the velocity.
b. The aerodynamic characteristics of the body vary with its attitude to the air stream.

As a result, the equations of motion become incapable of solution. Professor G. H. Bryan, as early as 1908 or 1909, met the difficulty by borrowing from Routh's Dynamical Stability of Small Oscillations, and introducing the idea of resistance derivations. By the introduction of resistance derivations, and by limiting the displacement of the airplane to small magnitudes from the equilibrium condition, Professor Bryan was able to reduce the equations of motion to linear differential equations with constant coefficients. There followed a theory of the dynamic stability of the airplane for small oscillations. By retaining the notion of the resistance derivative and introducing Heaviside operators, it is also possible to study limited motions of the airplane. But once the oscillations become large, or the application of the controls powerful, the resistance derivatives no longer apply, the equations of motion lost constancy in their coefficients and become insoluble. Even in studying a relatively simple maneuver, such as the dive and subsequent recovery, we have to resort to step-by-step integration, or to rational solution through a series of short intervals. More complex maneuvers, such as the barrel roll, have so far not yielded to analysis. A real opportunity would appear to exist for mathematicians to evolve a method of investigating all maneuvers or displacements whatever their magnitude and complexity.

2. *Flutter*

The investigation of flutter is very similar in principle to the investigation of the dynamics of motion of the airplane. Resistance derivatives are again introduced, and solution of the equations of motion leads to a discriminant and the application of Routh's Criteria of Stability. But after the criteria have been applied and it has been determined whether the wing is stable or unstable in the self-excited vibration which is termed flutter, there is tremendous complexity in interpretation. It is very difficult and very lengthy to determine what are the factors which are desirable and what are the factors which are undesirable. Graphical methods will shorten the labor of solution, but a rational mathematical process would be helpful.

3. *The Theoretical Design of Airfoils*

The earliest example of the mathematical design of airfoils goes back to Jonkowski in Russia, several years before the first great war. The method is one in which a cylinder and the flow round a cylinder are transformed by appropriate functions into an airfoil and the flow round an airfoil. The difficulty is that the airfoils derived by this method are not of the character which are both structurally and aerodynamically desirable. A number of modifications of the Jonkowski process have been essayed by writers in England, France and Germany, but the most desirable modern sections, those with the position of maximum camber far forward have not been produced and again an opportunity exists for the expert mathematician.

4. *Elastic Instability of Thin Skin Covering*

To the mere engineer, no branch of theoretical physics is so frequently tantalizing as the theory of elasticity. Those simple and well defined problems which can be solved by the theory of elasticity, can either be solved by the approximate methods of strength of materials or else are of no particular interest. Those which are really of high practical interest do not yield to the methods of theory of elasticity. For example, there is no rigorous method of solving the problem of the flat plate in edge compression when working in conjunction with a channel or stringer. No more beautiful problem could be placed before the mathematician.

5. *Potential in Compressible Flow*

Once we grant that a perfect fluid, that is, one without viscosity, exists, we can set up a potential function and investigate with

facility the flow past a cylinder, or the airfoil into which a cylinder has been transformed. But the methods involve the hypothesis that the fluid is incompressible. When we are dealing with a compressible fluid such as air, there is no potential function to help us. It would be highly desirable to devise a potential function covering the flow of a non-viscous but compressible fluid.

Conclusion

Other problems might be cited, such as the rigorous solutions of the equations of motion of a viscous fluid past a boundary, the strength of a plate composed of different materials (*i.e.*, plywood), the torsional strength of an irregular form. The message of the teacher of aeronautics to his mathematical colleagues is two-fold. In undergraduate instruction there should be application. For the research man aeronautics offers a boundless field.

(Continued from page 387)

sons, looking the other way, say it is a thing of beauty and should be a joy forever. Others admit that it needs propping up. Still others, I suspect, would like to see it topple over just for the fun of it. I think it should be both propped up and rebuilt according to a plan, remade piece by piece and promptly before it falls down. I imagine it may have to be many times reconstructed on still better plans. Thus, I think we need a thoroughgoing criticism of the present economic system, done very much in the manner and the spirit of Voltaire with his light but moving touch. And civil engineers along with the rest of society should learn to understand this criticism and to profit by it and to build in accordance with it.

Voltaire was not the devil he was painted, neither was he a saint, neither are you economists, as probers of our present economic disorders. But you, like him, are doing a necessary job and I hope your skeptical followers may be as numerous as his. At any rate I want my students to be among them.

AVIATION MEDICINE IN THE EDUCATION OF AERONAUTICAL ENGINEERS *

By JOHN D. AKERMAN

Professor and Head, Dept. of Aeronautical Engineering, University of Minnesota

We know that through mere necessity sanitary engineering had to collaborate very closely with the medical profession in problems where public health was concerned. It was obvious that the work that the sanitary engineer was doing had ultimate physiological effects on the human body.

Aeronautical Engineering in the past was concentrating to develop the flying machine which operated at lower speeds, acceleration, and altitudes where the physiological effects on the pilot and crew were not noticeable or important.

The art of design of flying machines is advancing to a stage where the flying machine is taking the human being into situations different than the ones he is accustomed to on the ground, or in other types of transportation. It is interesting to note that a standard textbook still in use has the following quotation: "The stratosphere, however, begins at too great a height (32,000 ft.) to be of much practical interest in aeronautics at the present time, and it will not be necessary to examine the properties of that layer in detail." It is obvious that such a statement is obsolete today and any modern aeronautical engineer now is faced with two main problems:

1. To develop flying machines with exceptional performance.
2. To provide means so that the personnel of the plane can function properly during the performance of the plane.

The responsibilities of the engineer to take care of the crew in the aircraft is not confined to flying at higher altitudes only. With the development of the flying machine, even at lower altitudes, the flying machine puts the human being in circumstances where his physiological well-being is affected. To name only a few of these: the effect of acceleration, fatigue, comfort and safety.

Each of the items above is a big field undergoing large scale investigations and in many cases the effects of the function of the

* Presented at the 50th annual meeting, S. P. E. E. (Aeronautical), New York City, June 27–29, 1942.

flying machine on the human being have been found. In some cases the medical profession has found solutions to eliminate the bad effects produced by the flying machine on the human being, but most of the solutions are technical and have to be solved, or have been solved by engineers. A very interesting example of that is found in German literature in 1939 where the medical profession established that the pilot in a horizontal position can withstand much higher acceleration than in an upright or sitting position, and at that point the medical profession simply stated that it is the engineer's problem to develop a machine in which the personnel could fly in a horizontal position. As a result in 1941 the first German planes were shot down with the pilots flying in horizontal positions.

Another good example I migh refer to is the case in the United States and in Germany where the medical profession established the exact amount of oxygen necessary for pilots flying at different altitudes, but then the problem was thrown into the hands of the engineers to develop apparatus which would supply and meter out the proper amounts of oxygen to the human being at different altitudes and in different flight situations.

The medical profession has discovered the bad effects of different gases on the personnel of the flying machine but it is a problem for the detail designers of the airplane to provide equipment which would rid the airplane of those dangerous gases.

We might also look at the picture from the other side.

Aeronautical engineers designed airplanes with such rate of climb that the change in altitude produced pains and it was the medical profession who showed the dangers to which the pilot is exposed in such a climb and also a way to avoid these pains.

Aeronautical engineers designed supercharged cabins but it was the medical profession who brought to the attention of the designers the dangers to which the crew is exposed, particularly military aircraft in such supercharged cabins, and again it was left to the engineer to modify the supercharged cabins or re-equip them so that the danger would be eliminated.

Those are a few cases which demonstrate the interdependency of the work of the aeronautical engineer and the man in Aviation Medicine. Many other cases could be cited but are omitted from this paper for reasons of secrecy.

The whole thing might be summarized in two statements:

1. The flying machine has advanced so far that many times the human being cannot follow the functioning of the machine.

2. The human being can perform those functions, provided the plane is properly equipped to take care of the personnel.

At the present writing there is not an airplane company or air transport company which does not recognize the importance of the physiological effects on the crew and that sometimes those effects terminate or limit the proper functioning of the airplane. Airline pilots and test pilots have all recognized the necessity of becoming acquainted with the physiological problems affecting the human being in different flight positions, and most of them have devoted considerable time getting acquainted with the work of the medical profession. In most cases they are faced with the problem of the medical profession stating that such and such equipment or provision should be installed on the airplane, but when they returned to the airplane, such equipment was not available or impossible to install.

Naturally the problem went back to the engineer to install this, change this, or develop this, on the airplane in order to take care of the personnel.

Now, in turn the engineer was faced with the problem of developing equiment the purpose of which was not clear to him. In any rational engineering problem the first requirement is for the engineer to know what the function of his product should be and then produce the best equipment.

A very familiar case which I might quote concerns the requirements given to the engineer stating that in supercharged cabins a definite amount of air is required per man per minute. The engineer faced with such simple specifications met the requirements but with results sometimes far from those desirable.

I am very pleased to note that the most progressive airlines and airplane builders have all detailed men on their engineering and research staffs to study the physiological effects on the crew as imposed by the flying apparatus or equipment, and many of the men are trying to study those questions by reading medical literature or directly associating with personnel of Aviation Medicine sections. How well pleased those companies would have been if they could have found their engineering or research staff men already well-versed and familiar with basic principles of physiological effects on the human being produced by different flying situations! It seems reasonable that the modern aeronautical engineer who will be participating in the design, or maintenance, or operations of modern aircraft should have some background at least in a general way of information on the physiological effects this flying equipment might produce on the personnel. How the problems will be presented in the future to the aeronautical engineering students in different institutions is still an open question with room for suggestions and trials, and for the sake of construc-

tive criticism I am presenting some facts on the pioneering work in this line done at the University of Minnesota.

In 1935 the Department of Aeronautical Engineering at the University of Minnesota created a professorship in problems pertaining to the stratosphere. As an elective course it turned out to be very popular with the students but a very troublesome course for the professor because in the course of study and research in the problems pertaining to the stratosphere, he was faced with a situation where he did not know what he should know about the stratosphere, and once he found a topic which he should know about high altitude flying he very often did not have the solution for the problem. But even at that many creative ideas and problems were undertaken and solved, which have resulted in practical application for everyday use on modern aircraft.

It was natural that he immediately was faced with some physiological problems for solution or investigation on which he had to have the help of the medical profession.

In the school year 1939-40 a close coöperation by the Department of Aeronautical Engineering and the Aero-Medical unit of the Mayo Clinic was established, and the senior class of that year, through trips to the Mayo Clinic, and through discussions in Seminar, had the opportunity, I should say, to expose themselves to some of the work of the Aero-Medical unit of the Mayo Clinic. Students and faculty members made ascensions in the high altitude chamber at the Mayo Clinic and often volunteered as subjects for collection of data.

During those contacts it was obvious to the personnel of the Aero-Medical unit of the Mayo Clinic and the faculty of the Aeronautical Engineering Department of the University of Minnesota that it would be advisable to establish a permanent contact between the two departments, and as a result the Mayo Foundation gave a generous fellowship for one man; so that, he could spend half time at the Aero-Medical unit in Rochester and half time in the Department of Aeronautical Engineering and that the work for a Master's Degree would include work where the physiological and engineering problems were interwoven.

As the first fellow, whom I would like to call the "missing link" between Aviation Medicine and Aeronautical Engineering, Mr. Norvin E. Erickson, was chosen, and his work in the Mayo Clinic, although handicapped by 20-letter words and medical terminology, was so satisfactory that the next year the Mayo Foundation agreed to continue this type of fellowship, and as soon as more funds are available at the University of Minnesota, similar fellowships will be established.

(Continued on page 401)

CHEMICAL ENGINEERING EQUIPMENT DESIGN *

By J. H. RUSHTON

Professor of Chemical Engineering

AND

H. C. HESSE

Associate Professor of Mechanical Engineering, University of Virginia

Chemical engineering, as the vigorous younger brother of the family of engineering professions, has doubtless profited by the experiences and mistakes of the older generation. In common with many juniors of a family group, however, the newest field of engineering practice has fallen heir to much of the non-chemical material that the older branches of the professions have found useful, and which must therefore (in their opinion), be of interest and utility to the chemical engineer.

We all recognize the value of basic courses in mathematics, graphics, and mechanics, and realize that a successful career in any branch of engineering is impossible without their aid. It is somewhat more difficult, however, to see why courses in strength of materials, machine and structural design, and allied material, designed and planned for civil and mechanical engineers, should be presented to the chemical engineering student without extending the adaptations to his special interests and applications. The present-day courses in chemical engineering curricula in strength of materials and design are broad in theory, but are usually taught without an appreciation of chemical engineering applications. In many instances, the courses in structural and and machine design are too limited for the chemical engineer, because they stress only those problems usually encountered in the mechanical processing fields. The rapid development of chemical processing has resulted in a demand for equipment such as heat exchangers, autoclaves, stills, etc., on which there is comparatively little emphasis in other branches of engineering, although the basic design data are essentially of a mechanical rather than a chemical character. This state of affairs calls for development of a more suitable course

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to extend the basic principles of strength of materials and design to the chemical equipment field.

At Virginia we have combined the courses in Strength of Materials and Machine Design into one carefully integrated course in the Design of Chemical Engineering Equipment. This course has been in operation during the past three years and we feel that it has been a step in the right direction and is broadening the applications of basic theory. It is taught by a man whose experience has been in the field of equipment design, and its content and emphasis are dictated by the needs of the chemical engineer.

The course is intended to give the young engineer an insight into the fundamentals of design of chemical equipment. The technique used varies from the ordinary concept that strength of materials courses and design courses are separate entities; the results, however, seem to indicate that these two courses not only can be given as one, but that it is probably desirable to do so. We are not attempting to make the graduate chemical engineer a design specialist for a chemical equipment manufacturer—that is still the function of the mechanical engineer. The chemical engineer must, however, have a sufficiently comprehensive picture of the design field so that he may realize the possibilities and limitations of equipment construction and installation. He should be able to make preliminary studies of designs so that comparative equipment costs can be estimated at an early stage in process developments. He must be able to transmit plans and ideas, consistent with the chemistry involved, to designers of commercial equipment, and to suggest or make inquiry for the use or adaptation of standardized or stock equipment, without too much reliance upon the opinions of equipment salesman. He should be able to modify or redesign existing equipment for processes in operation. Thus the chemical engineer requires a specialized course in design, selection, and adaptation of equipment, based upon the fundamentals of the usual courses in strength of materials and machine design.

The course is given in the senior year after the student has completed all of his physical chemistry, studies of the process industries, and unit operations. The students are somewhat matured by this time, have the background to appreciate the significance of the work, and can absorb a large quantity of material in a short time. At present the course is given in a nine week term with three lecture hours, and two laboratory periods of three hours each, per week. We are planning to extend the course time by adding an extra lecture hour per week and possibly a few more laboratory hours. This time would then be equivalent to a semester program with three lectures and six laboratory hours per week. The out-

lines of the course which follow show the content of the lectures, the laboratory (principally drafting room) work, and the correlation between lecture and laboratory. A minimum of one and one half hours of study, preparation, and preliminary problem work for each hour of lecture time is presumed. Lecture material, preliminary problems, and laboratory assignments are furnished to the student in mimeographed and print form, although we hope to expand this material into a suitable text in the near future.

Outline of Lecture Course for The Design of Chemical Engineering Equipment

1. Introduction
   Interrelation of material characteristics and properties with design procedure; review of methods of measurement and specification; graphic representation and convention.
2. Elementary Stress Analysis
   Elasticity, plasticity, fatigue, creep, gas embrittlement, etc.; simple stresses; deformation; tensile testing and application of stress-strain diagram.
3. Elementary Stress Analysis
   Proportional and elastic limits; yield point; comparison of induced and design stresses and factor of safety; analysis of a cottered joint as an example of simple stress analysis.
4. Riveted Vessels
   Analysis of stresses in walls of cylindrical vessels subjected to internal pressure; description and analysis of riveted joints; riveted joint efficiencies.
5. Riveted Vessels
   Summation of ASME Unfired Pressure Vessel Code; description, proportions, and selection of flat and dished heads; manholes and closures.
6. Welded Vessels
   Description of welding and allied processes; summation and application of ASME-API Code for welded pressure vessels.
7. Welded Vessels
   Summation and application of ASME-API Code for the design of reinforcement for openings; spherical and hemispherical vessels; jackets.
8. Mechanics
   Graphical statics; analysis of forces in brackets, supports, and trusses; definition and types of beams and beam loadings.
9. Mechanics
   Beam stress analysis; shear and moment diagrams; moving loads.

10. **Structural Design**
Summation and application of AISC Code for Structural Design; allowable stresses for rivets, welds, tension and compression members, and beams; column design.
11. **Structural Design**
Design of riveted joint trusses and brackets; types of loads; selection and specification of members and rivets.
12. **Structural Design**
Design of welded brackets, supports, and attachments.
13. **Combined Stress Applications**
Principal stress analysis and theory; primary and secondary stresses in riveted joints; stress concentration.
14. **Threaded Fastenings**
Description and application of screw threads and bolted joints; initial tightening stresses; design of bolts for pressure vessel heads and closures.
15. **Closures**
Analysis of plate and cover designs; summation of ASME-API Code for cover and removable head design; gaskets and packing.
16. **Plates**
Plate theory; design of fractionating column plates and supports.
17. **Pipes, Tubes, and Attachments**
Tubing design formulae; pipes, pipe threads, and fittings; valves, sight glasses, and thermometer attachments; expansion joints.
18. **External Pressure Vessels**
Summation and application of ASME Unfired Pressure Vessel Code for vessels subjected to external pressures; design of tubing for external pressures and for high temperatures.
19. **Power Transmission—Belting and Chains**
Power units; summation and application of ALBA data for leather belt selection and design; analysis and application of rating and design tables for V-belt and V-flat drives; analysis and application of rating and design data for chain drives.
20. **Power Transmission—Gearing**
Description of gearing; principles of operation; velocity ratios; design charts for spur, bevel, and worm gear selection; application of helical gearing to special center distances.
21. **Power Transmission—Speed Reducers**
Description of geared and other types of speed reducers; summation and application of AGMA data for geared speed reducer selection.

22. Power Transmission—Shafting
    Analysis of torsional stresses; summation and application of ASME Code for the Design of Power Transmission Shafting.
23. Power Transmission—Bearings
    Bearing types and principles; design and selection of plain bearings; summation and application of manufacturer's data on ball and roller bearing selection and application.
24. Bases and Supports for Machinery
    Comparison of cast and welded construction for machine bases; base design; vibration-free bases.
25. Bases and Foundations
    Reinforced concrete construction; summation and application of AISC Code for the design of beams and slabs; foundation design.
26. Non-Metallic Construction
    Wooden beams; wood tank construction; glass and other linings.
27. Plastics
    Types; fabrication; applications and design details.

Laboratory Assignments and Projects to Accompany the Lecture Course in the Design of Chemical Engineering Equipment *

Periods		
Lec.	Lab.	
1.		
2.	A	Isometric Layout of Acid Tank Piping System.
3.	B	Tensile Testing Experiments in Structural Laboratory.
4.		
5.	C	Design computations and detail drawings of a benzene
6.	D	still (cylindrical pressure vessel) with riveted joints.
7.		
8.	E	Design computations and detail drawings of a welded-
9.	F	joint autoclave with flat heads and reinforced openings.
10.		
11.	G	Analysis of a roof truss to determine the feasibility of
12.	H	attaching supports for overhead storage tanks.
13.		
14.	J	
15.	K	Design computations and detail drawings of a shell and
16.		tube heat exchanger.
17.	M	
18.	N	
19.		Design of a fractionating column plate.
20.	P	

* Lecture hours are correlated with laboratory periods, and are indicated by letters, and consist of three hours each.

21.	Q	Design and selection of flat belt, V belt, and chain drives
22.		for a gyratory crusher.
23.	R	Design of spur and helical gear drives for dryer kiln.
24.	S	Analysis of countershafting for a ball mill.
25.		
26.	T	Selection of a worm-gear speed reducer for a motor-driven diaphragm pump; design of welded base for unit.
27.	U	Design and detail drawings of foundation for absorption tower.

(Continued from page 395)

The training of those Fellows was well appreciated by industry which offered generous salaries to hire those Fellows and by the Army Air Corps who left the present Fellow at the Mayo Clinic even though he was a commissioned officer in the United States Army Air Corps Reserve.

As a result of those Fellowships and close coöperation of the personnel of those two departments in research problems, the students of the Department of Aeronautical Engineering, who have expressed a desire to get acquainted with the physiological questions met in aviation, have had ample opportunities to do so. This close coöperation of the two departments has not been one-sided for the benefit of aeronautical engineering only but has also helped in many cases the medical men, and many research problems now going on at a national scale have been possible only because of this close coöperation.

The value of this coöperation was appreciated by the medical men and was expressed by Dr. Randolph Lovelace when he donated funds to the Aeronautical Engineering Department to secure a high altitude chamber for use at the University, thus helping the Department to keep abreast and continue teaching and research in problems pertaining to high altitude flying which the department started in 1935.

COLLOID CHEMISTRY IN CHEMICAL ENGINEERING COURSES

By ERNST A. HAUSER

Associate Professor in charge of Colloid Chemical Laboratories, Massachusetts Institute of Technology

We are offering in the first term of the academic year a course entitled "Introduction to Colloid Chemistry," which is designed specifically to cover the chemistry and properties of colloidal systems. The chemistry, properties and uses of organic and inorganic plastics and elastomers is taught in a special course. Also we are offering an elementary laboratory course in colloid chemistry. In the second term a course is given in advanced colloid chemistry and a course covering the industries based on colloidal raw materials. Also an advanced laboratory course is given. If warranted by registration, the introductory course and the one dealing with plastics are also offered in the second term. Although these courses are are also offered in the second term. Although these courses are listed as elective graduate courses, seniors, and juniors of high standing, are permitted to enroll.

For students in the departments of biochemistry and biological engineering the introductory and advanced courses in colloid chemistry have been compulsory for a number of years. The curtailment in the teaching staff in the chemical engineering department has postponed at least for the duration making the elementary course compulsory for students enrolled in chemical engineering. However, following the old proverb that the best proof of the pudding is in the eating, compulsory enrollment is secondary in importance to enrollment by free will. This is especially the case if other elective courses are offered which are definitely easier. Therefore a glance at the enrollment figures for some of these courses is enlightening. The registration for the elementary course in the academic year 1935-36, when it was offered for the first time was 20. In 1936-37 it increased to 35, in 1937-38, 45; 1938-39, 52; 1939-40, 65, and in 1941-42 there were 88 students enrolled.

The course in high molecular compounds which was offered for the first time in 1940-41 showed an enrollment of 40 in both terms, and in the first term of 1941-42 it increased to 55. Another indication that the students are taking an increasing interest in this

field of science, and particularly in its application to chemical engineering, is the constantly increasing number of students seeking thesis subjects in these fields. This development indicates better than any propaganda write-up that colloid chemistry has finally, admittedly after a hard struggle, won its place in the curriculum of a chemical engineering student who wants to keep abreast of modern developments.

Unfortunately there are still many "dyed in the wool" teachers of chemistry who take the attitude that colloid chemistry is nothing more than fumbling around with impure systems and that nothing can be gained by stubbornly pursuing the study of colloidal phenomena. This attitude is serious and dangerous because industry realizes more and more how important at least a basic knowledge is if not a complete one of colloidal phenomena and properties of matter when in the colloidal state.

I believe that the simplest way to explain this all-important point would be to cite a number of specific examples:

The problem of heat transfer in chemical equipment is as we all know, of extreme importance. We have gone quite far in the evaluation of this factor under most varied conditions. However, very little has been done to find satisfactory explanations for results which are not in accord with theoretical calculations. The effect which films of colloidal or even molecular dimensions have on the changes in heat transfer from a surface is known, but very little has been done toward a systematic study of it. It is not at all necessary for a highly polished surface to become coated to cause a noticeable change in heat transfer, but by filling up any surface irregularities the heat transfer of the system is bound to change. The prevention of such scale formation by the use of dispersing agents or protective colloids, as the case may be, is one of the many examples where colloid chemistry is directly applicable to a unit operation.

Inasmuch as colloid phenomena are quite generally the result of reactions occurring in greatly developed surfaces, it is only natural that anything in which surfaces play a prominent part is of colloidal nature. Therefore, problems of filtration and adsorption call for a colloidal approach even if the reacting substances as such are not necessarily colloids by customary definition. Too seldom does one realize that rate of filtration and drying of the filtercake are not solely controlled by the type of substance or its particle size, but by particle shape and the entire prehistory of the suspension have a great deal to do with the rate of filtration and subsequent drying. If we make a fine particle size suspension of a given substance, stabilizing one part of it either by increasing

the electric charge of the particles or by the use of protective colloids and adding sufficient electrolyte to the other part to cause flocculation, a noticeable difference in the rate of sedimentation or filtration as well as in the sedimentation volume will result.

I could keep on enumerating such examples but I would like to limit myself to these and refer to some specific industrial applications. Nevertheless it should be evident from the foregoing that the teaching of colloid chemistry to the chemical engineering student is of extreme importance even in such basic fields as unit operations which have always been considered specific and sacred to the chemical engineer. Naturally this calls for the teaching of colloid chemistry in a somewhat different fashion than it might and probably should be taught in a curriculum devoted strictly to chemistry. Very few outside of the ranks of the professional colloid chemists and the progressive paper manufacturers have realized that the successful sizing of paper is the result of an extremely complex electrokinetic reaction between the negatively charged paper fibre, the negatively charged rosin emulsion, and the alum which dissociates into positive aluminum and negative SO_4 ions. While the SO_4 ions combine with the alkali of the rosinate, thus depriving the emulsion of its stabilizer, the aluminum ions cement the rosin and the paper together. The ill-famed pitch problem also calls for knowledge of colloidal phenomena. That it can be successfully solved as a result of colloidal research has recently been demonstrated in one of the largest paper mills of this continent and this work has been done by a man who had taken courses in applied colloid chemistry in his chemical engineering curriculum.

The inroads which colloid chemistry has made in ceramics during the last years are beginning to tell. Not only has this new approach to this age old craft enabled us to explain a number of facts for which classical chemistry could not find any answer, it has begun to change the entire production of certain articles. I believe there is no need to emphasize the fact that a chemical engineer without any knowledge of the colloid chemical background of the industry could not very well be considered the ideal man to be put in charge for redesigning the plant.

Even an industry as remote from what we generally consider a chemical industry as the laundry industry is full of colloidal problems. The chemical engineer should know all possible about water-softening, water-purification, and water-conditioning. It is not sufficient in my opinion to obtain such information, when the situation demands it, from pamphlets issued by companies interested in the sale of such agents. Neither is it sufficient to consult a library for some of the more recent scientific publications on this

subject. To do a good job it is essential that the chemical engineer be fully familiar with the fundamental phenomena involved.

I have purposely omitted discussing catalysis since this has already been taken care of in the preceding program. I do, however, want to point out that heterogeneous catalysis in particular is strictly a colloidal phenomenon.

At the end of my discussion I want to spend a few minutes on a subject which is today very much in our minds: Rubber and plastics.

The rubber industry, and in particular that part of it which applies to liquid rubber latex, is a colloid industry par excellence. Here the chemical engineer with a well-founded knowledge of colloid chemistry finds himself in a paradise. Every step in the processing of crude rubber and in the production of finished rubber articles direct from latex is based on properties typical of colloids or colloidal systems. For example the changes rubber undergoes on the mill, the compounding process, and the process of vulcanization, controlled coagulation of latex, and many others. The advent of synthetic elastomers and the increasing number and importance of synthetic plastic resins have put a new burden on the up-to-date teaching of applied colloid chemistry. It has become necessary to introduce detailed discussions of the mechanism of polymerization as well as the methods applied, to elaborate on the structural changes of the substance during polymerization, to explain the structural differences between thermoplastic and thermosetting materials.

It would be a grave mistake to take the attitude that all this is of no importance to the chemical engineer and should be reserved for the domain of the chemist. We are once again at the threshhold of a new synthetic industry, easily comparable in importance to the development of the dyestuff industry in this country after the first World War. We shall need an ever increasing number of well-trained chemical engineers, especially qualified to build, run, and constantly improve this new chemical venture. But to be so qualified means to me to have as complete a knowledge as possible of every step involved in the production of these new materials and not only to know—perhaps—what they are, what purpose they should serve, and what their appearance is.

I am fully aware that what I have presented cannot be considered a finished picture such as an artist would display; it represents merely a rough sketch. Even if I should have the material at my disposal to finish the picture, I am afraid that the time necessary would not be available during this meeting. I believe, however, that even the sketch will suffice to emphasize the points which have convinced me that colloid chemistry has become an essential factor

in modern industry and therefore an essential part in the training of our future chemical engineers.

However, as a result of several years of teaching experience in this particular field I am equally convinced that colloid chemical engineering must be taught differently than colloid chemistry is being taught as a rule. A successful colloid chemical engineer must not only be in possession of the fundamental laws controlling colloidal phenomena, he must also be able to see how and when to apply this knowledge correctly. This calls for a keen observation. It is therefore necessary to encourage the student to improve his powers of observation and to teach him how to make full use of them when trying to solve all kinds of industrial problems.

I can say without hesitation that we have been extremely successful in this respect by introducing into some of our courses in colloid chemistry what we term experimental quizzes. The professor performs a few experiments in front of the class disclosing in detail to the student every step of the experiment. The student has then to offer a written explanation of the phenomenon observed, or the mechanism of the reaction he has witnessed. One may compare this type of quiz in colloid chemistry with the customary problem type of teaching in other fields of chemical engineering. I consider the results of such quizzes most enlightening from the point of view of the student's future success in his employment. I have frequently found that students showing high ratings in regular quizzes failed completely in experimental quizzes, whereas others of medium standing excelled in these experimental problems.

I do not know your reaction to these facts, but from the point of view of an industrialist employing a young man as a chemical engineer, I certainly would take the one who, even if not absolutely tops in reading tables or setting up equations, could use his eyes as a first-class tool for observation.

EXPRESSION AS AN ENGINEERING TECHNIQUE *

By JOHN J. O'NEILL

Science Editor, *The New York Herald-Tribune*

Every expression in writing is an experiment in communicating knowledge. For this reason we should adopt functional principles of design in formulating our written expressions. They should be entirely utilitarian. This plan does not eliminate but, of necessity, includes esthetic considerations.

There is a high order of correlation between beauty and clarity of expression. A slovenly designed and constructed sentence is an unsafe container of knowledge.

An individual's mode of expression in written language is an integral part of his personality, as much as his mode of speech, his manner of walking, the shape of his nose or the proportions of his body. This would appear to be a fatalistic viewpoint which would condemn some individuals to a limited expression, but this is not necessarily the case. Nature provides a wide range of latitude in the utilization of all of our faculties. Rarely does the best endowed individual use more than a small fraction of his ability for formulating clear, terse information. The poorly endowed individual by developing and using a larger fraction of his ability can equal in quantity and quality, the average output of the better endowed individual.

Use of written language presupposes the need for conveying knowledge. The greater the amount of knowledge possessed by the writer the greater is the amount of information he can load on the smallest number of words, and the greater is the clarity of expression that he can achieve.

Self assurance on the part of the writer concerning the possession of knowledge is of greatest aid in achieving clear, forceful expression that carries assurance to the reader that what is read is worth assimilating into the body of knowledge already possessed. Beauty of expression makes the calories of knowledge more appetizing.

A piece of writing should be as much a living thing as a new born child, and should pass through the same cycle of creation. There should be a very specific reason for creating a piece of literary composition, technical or otherwise. Without the reason for

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its existence a composition will be an amorphous mass of words. The reason for writing any kind of a composition determines its structure, style and content. The reason for the existence of a composition corresponds to the conception of a child. It is at this point that the new individual receives, through the mechanisms of heredity, the pattern of its future form and all that makes up its existence. *The basic idea, for a composition, in the mind of the writer is in the same situation as the fertilized ovum in the* womb of its mother. The idea must be supplied with nourishment in the form of specific data and information. There is a right time for child and a composition to be born. Many a foetus is resorbed into the mother's body and this should happen with a composition when it is found that the reason for its existence cannot be justified.

Before actual composition is started all necessary information should be on hand or the supplying of it, as needed, should be assured. Just as a child, to be a useful member of society should bear all the parts, mechanisms and functions that identify him as such and permit him to fit into the activities of the rest of the race, so should every composition be supplied with all the information that will enable it to make an interlocking fit with all other contributions to knowledge with which it will make contact. Until the composition has been so shaped it is not ready to be born.

Each composition, or article, is a stone in the temple of knowledge, some mechanism useful in the shaping of the stones, or some revelation concerning the blue print of the unknown plan of the temple or the use of the functioning portions of the edifice. A writer, once he has ascertained that his stone is compounded of and is four square with truth, should not be fearful concerning its place in the temple because its place seems to be far from the foundation. It may be the foundation stone for a very useful flying buttress, or a new wing. Nor should the contribution be despised because it is just one stone in the slowly rising walls—for of such is the temple constructed, and without them there would be no structure of knowledge.

It is the observation of the writer, in a long experience in writing articles on scientific subjects for newspapers and magazines, that there is an emotional factor involved and that the subconscious plays as important a part as the conscious realm of our mentality in producing an article against a fixed time deadline. During the past decade his published output has averaged more than 300,000 words a year, half of it in articles of more than 1,000 words and the remainder in minor items. Unpublished books and articles (written usually for the purpose of letting off steam) poems, songs and correspondence would double the foregoing figures.

The chief item in my output has been a "lead" article of about 1,500 words on a scientific subject which must be timely in nature and must be finished by 4 P.M. on Wednesday of each week, along with an equal number of words in many smaller items, plus photographs for illustrations. In 15 years nearly 800 such articles have been written and at times the matter of subject, or "reason" for writing, becomes a problem. Current events frequently determine my subject; at other times the problem becomes more acute. I am always assembling material in my files for future use, and these folders frequently supply nourishment for an idea.

I decided recently, for no good reason, to write an article on weather, a subject of perennial interest. I read my accumulated files which proved to be an utterly useless mass of absolutely sterile material. The major part of a day wasted, including mail, telephone and visitors. Why did I pick the weather as a subject? Too late now to change and do an equal amount of research on some other subject. I should start three days sooner to allow for such situations. I can't fail to produce my material on time! Re-examination of material. Hopeless. Three or four cigarettes to boil the cerebral protoplasm. No ideas. Nice weather out. Why didn't I do this article three days ago and take today off. Wonder if we will have a warm summer. Might be able to guess if I had some data from the polar regions. Wonder if the polar high pressure air mass is tilting back toward the American side; it was over the Russian side last winter producing severe temperatures on the battle fronts. Must have dropped off so many chunks of its cold air mass that it will probably oscillate toward Alaska and drop them off there next winter, meaning cold weather on this side of the world as the cold air masses slide down from Alaska. Boy, bring the latest editions of the papers—usually left unread. Eye catches headline about military activities in Aleutian Islands; operations hindered by bad weather. There was my story! Aleutian Islands as the weather Garden of Eden, where storms are born. Some data left over from my studies of Russian weather came in useful. Most of my material came from my memory files, talks with meteorologists which never blossomed into a story. A telephone call to the Weather Bureau to clear some doubtful points. My story framed itself beautifully into a background of front page news. It almost wrote itself. I hardly had to do a thing, just feed the pages into the typewriter. Six triple spaced pages and the story was "born."

The details are different each week but the basic situation and the net results are always the same. Only a particular type of individual would get himself into and out of situations in that irrational manner. Fortunately, or unfortunately, that seems to be the type that survives in the writing game.

THE GENESIS OF THE COÖPERATIVE IDEA *

By CLYDE W. PARK

Professor of English, College of Engineering and Commerce, University of Cincinnati

Although Herman Schneider is rightly considered to be the founder of the coöperative system of education, his own wish was to avoid an assumption of single-proprietorship and to recognize his indebtedness to people and circumstances. The question of crediting arose pointedly in 1915. I was writing an account of the coöperative system, which was published a year later as Bulletin 37 of the United States Bureau of Education. At that time the system was often referred to as the "Schneider plan" or the "Cincinnati plan," since it was associated exclusively with the name of its founder and with the University at which it had been in operation for nearly a decade. I asked Dean Schneider his preference as to the use of these and other identifying expressions. He strongly opposed including the name of a person or a place in the designation of the coöperative system. He believed, he said, that the system was bigger than one man's ideas or one college's particular application of its principles. Out of respect for his definite views on this point, I made the story much more impersonal than I had intended.

It is true, as Dean Schneider said, that the coöperative plan was broader than any localized version of it would suggest. It is also true, as he frequently pointed out, that by its very nature the plan was not a one-man enterprise, but called for team work in the joint efforts of many participants. But in the beginning there had to be something around which team work could be organized. Individual inventiveness and initiative was required to create the plan, some one's persistence was needed to launch it, and its successful operation called for a high quality of leadership.

Because the origin of the coöperative system is inseparably linked with the character and experiences of its founder, the growth of the idea must be traced largely in biographical terms. Through the accident of circumstances and the dictates of his own inclinations, Herman Schneider received a kind of training which antici-

* Presented at the 50th annual meeting, S. P. E. E. (Coöperative), New York City, June 27–29, 1942. Part of the paper is condensed from a biography of the late Dean Herman Schneider.

pated many points of the coöperative system. The significance of this fact was not clear to him until some years later, when as an instructor he began to think about the training of young people. Then he drew heavily upon his own experience, which he believed had been sufficiently typical to make it a trustworthy guide for students. Derivation of educational principles came afterward, as did also philosophical conclusions regarding methods and objectives in education.

Early in life Herman Schneider had some elementary preparation for the relating of education to industry. Born at Summit Hill, Pennsylvania, in 1872, he grew up in a mining community in which boys learned to work as a matter of course. For several years his spare time was occupied with odd jobs in his father's general store. At the age of fifteen, having finished the instruction offered by the local schools, he received permission from his family to go to work at a mine. At that time the standard day was ten hours long and the average wage for this class of labor was fifty to seventy-five cents a day. Though he was classified as a "breaker boy," Herman's principal task was to do errands for the mine's construction crew. In effect, he was personal assistant to the boss of the gang, a one-armed carpenter. This man allowed young Schneider to serve as his pencil and saw, and gave him extensive practice in laying out work or cutting patterns for the other men. He took a fatherly interest in his young helper and offered some advice. "If I had your education," he said, "I'd study engineering and learn to make blue prints. Then you could tell other people what to do."

Whether he was influenced mainly by this suggestion or by the example of his older brother Anton, who was studying civil engineering at Lehigh University, Herman Schneider made up his mind to go to college. After two years of preparatory work, and health building, at the Pennsylvania Military Academy, he entered Lehigh University as a student of architecture.

Soon after his arrival at Lehigh young Schneider obtained part-time employment with A. W. Leh, a local architect and construction engineer. Schneider served as messenger or "blue-print boy" on Saturdays and in free hours during the week. In time he advanced to minor design and some supervision. At the office he picked up numerous ideas about construction as he watched the growth of various projects that were handled by his employer. Also, he had frequent recourse to reference works in Mr. Leh's collection, most prominent of which was the office Bible, a copy of Kidder's "Architect and Builder's Pocketbook."

The alternation of study in college with related practical work was accidental in Herman Schneider's case, but a planned combi-

nation of the two could hardly have been better arranged. Even so, the educational value of his labor might have been much less except for the personal assistance given by his employer. Mr. Leh had approached architecture and structural engineering mainly from the practical side. In his youth he had served an apprenticeship not unlike that of other young men who were "reading" law or medicine in the office of a practitioner in order to fit themselves for a professional career. Although his formal study had been somewhat limited, his education had continued without interruption. He possessed an alert, inquiring mind, and he was extraordinarily well read on general subjects. Within his professional field he impressed upon his understudy certain principles and maxims drawn from his long experience. Typical of these was the quotation,

> Architecture is the ornamentation of construction, and not the construction of ornamentation.

Through his association with young Schneider he saw an opportunity to obtain some knowledge from authentic sources at the University. A standard question which he addressed to his apprentice on Saturday afternoons was, "Well, son, what did you learn this week?" The questions and discussions which arose between them at the office compelled Herman Schneider to think about problems and to seek information in a way that might not otherwise have occurred to him. Mr. Leh's favorite starting assumption, "There must be a reason for this," contained a challenge that could not be ignored by his assistant or by the college instructors to whom the question was relayed. For young Schneider, it was like having a college education, plus Mark Hopkins on the end of a log.

As he looked back upon his college course, Herman Schneider recalled that even his youthful labors at the mine had been of some help in connection with his studies. Part of his college work was a textbook course in wood frame construction. The students were to read an illustrated descriptive treatise on sills, rafters, beams, bearing partitions and so on, after which they were to make some assigned drawings similar to those in the book. It will be remembered that the one-armed carpenter for whom he worked had given young Schneider a thorough but most unbookish course in just this sort of thing. Cutting the bevel of a rafter for this man was not a question of theory but a practical assignment, on which there must be no mistake. In the eyes of the boss, seventy per cent accuracy would not have been a passing grade. Schneider told his instructor of his experience and asked that he be permitted to make some drawings and take whatever examination was given the rest of the students. He was excused from attending classes

in this subject, passed his examinations easily, and gained several afternoons of free time, which he spent in the architect's office.

The classroom work which made the deepest impression upon Herman Schneider was the instruction he received from Mansfield Merriman, Professor of Civil Engineering. In his teaching as well as his writing, Professor Merriman approached problems with a direct analytical attack that exemplified for his students the virtues of rigorous thinking. Those who were fortunate enough to be in his classes inevitably caught something of the mental efficiency, the intellectual integrity, and the uncompromisingly high standards which placed him among the foremost members of his profession. His lasting influence upon Herman Schneider recalls the dictum, "We teach as we are taught." It should be noted in passing that Merriman's contribution to engineering teaching extended far beyond the limits of his own institution. He was one of the organizers of the S. P. E. E., and his presidential address of 1896 is a landmark in the Society's history.

From Herman Schneider's graduation in 1894 to his return as a cub instructor in Professor Merriman's department at Lehigh, there is a lapse of five years, a period whose events may be described briefly as a "school of experience." Capitalizing the confidence he had gained while in Mr. Leh's employ, Schneider opened an office for the practice of architecture at Cumberland, Maryland. Successful in business, after weathering the initial starving period, he became ill of malaria and went home to recuperate. To rebuild his health, he went out West and worked with his brother Anton as a bridge engineer on the Oregon Short Line railroad. This time his standard reference book, both at division headquarters and on location, was Merriman and Jacoby's "Roofs and Bridges," Volume III. When the railroad's appropriation for a new construction was exhausted, he returned east, recovered in health, and enthusiastic over the possibilities of bridge engineering.

As an instructor, Schneider began to do some serious thinking about the training of engineers. His own observation and a comparison of notes with older men had convinced him that some sort of special preparation was needed to enable a young man to take hold of practical work upon graduation. The gap between college and industry, he felt, should be bridged in some way, in order to increase the young engineer's effectiveness and to avoid the risk of tragic disappointments. He puzzled over the problem, fascinated by its difficulty.

One evening, after teaching hours, he was pondering this question while he walked across the Lehigh University campus. Suddenly he was startled out of his reverie by the blast of a Bessemer converter at a near-by steel plant. In that moment an idea came

to him that offered a possible solution to his problem. Here was a huge modern industry existing side by side with a university—a vast industrial laboratory filled with the latest, the most expensive equipment, made to order for his scheme of training. At the end of their college course many of the young men now studying in Lehigh University would find employment in these steel mills, as other graduates had done before them. Why not have this employment begin on a part-time basis while they were in college, and make the work a recognized part of their training?

Only a hint can be given of the later growth of this idea and of its reception by his contemporaries. For more than five years Herman Schneider tried to "sell" the coöperative idea to educators and industrial executives, both in the East and in the Middle West. Encouraged by some teachers and ridiculed by others, he learned that great patience is needed by any one who would bring about an innovation in education. Although he was given a more sympathetic hearing by leading executives in such firms as Westinghouse, American Bridge Company, and the United States Steel Corporation, he found that here also was a real selling problem.

Meanwhile, he had been appointed Assistant Professor of Civil Engineering at the University of Cincinnati. After sending up a number of trial balloons, he finally obtained the sort of response he had hoped for. He had addressed a meeting, explaining his scheme for training engineers through coöperation between college and industry. A six-line report of the address, published on an inside page of a Cincinnati newspaper, chanced to attract the attention of Mr. John M. Manley, Secretary of the Cincinnati Metal Trades Association. At that time the machine tool industry of Cincinnati was beginning an expansion prophetic of the commanding place it now occupies. A committee of manufacturers had been studying the question of how to get better-trained engineers for their research and production needs. Mr. Manley arranged for Professor Schneider to meet with this committee and to make a series of calls upon individual manufacturers who might be interested. After months of patient explaining to doubting manufacturers, and to college teachers and a board of Directors who were even more skeptical, Herman Schneider gained permission to try the coöperative experiment on a small scale. This was the first example of a new type of training concerning which it is stated in the S. P. E. E. Report of the Investigation of Engineering Education (1923–1929):

Coöperative engineering courses as conducted in the United States are, however, a distinctive type of educational program for which little or no direct precedent can be found. It is probably both fitting and accurate to

credit not only the inception of the idea of such courses but also the position which the plan occupies in this country at present in large measure to the ability, resourcefulness, courage, and consistency of purpose of Dean Herman Schneider who first established coöperative engineering courses at Cincinnati in 1906.[2]

The success of the plan, its extension to other branches of industry, other types of engineering, and other colleges—these facts are well known. With the proverbial wisdom of hindsight, we can see that those industrialists who gave the suggestion qualified approval builded better than they knew. Certainly the machine tool interests could not have been expected to foresee a time when a considerable proportion of their executives would be engineers trained under the coöperative plan. Nor, looking beyond the Cincinnati area, could they have foretold how other engineers trained in this way would serve the nation's industry in key positions. To speak only in terms to the present crisis, the products of that now distant experiment include such men as Myron B. Gordon, Vice-president of the Wright Aeronautical Corporation, who recently returned to Cincinnati to direct the construction of a mammoth factory for the production of airplane engines; H. A. Wolsdorf, packaging engineer, loaned to the government to supervise the crating and shipping of lease-lend supplies; Craig Edwards, carburetion expert for the Bendix Corporation, who has been testing airplane motors in California, Northern Africa and elsewhere; Carlos Roby, Managing Director of the Cincinnati Milling Machine Company's branch in Birmingham, England; and Adolph Forester, previously of the Birmingham Factory and now Technical Adviser to Mr. Averill Harriman on lease-lend supplies. These men and hundreds of others are too busy doing a job to reflect upon the type of college training they received, but they are using that training for practical and important ends. Thus they are vindicating an idea which began forty years ago as a nebulous theory and established itself the hard way.

The coöperative plan was not put into practice anywhere until 1906, when Dean Schneider introduced it at the University of Cincinnati, but the idea seemed obvious and almost inevitable, once it was brought to people's attention. It was admittedly a new departure in education, and yet it seemed to be something that should have been done long before. Perhaps this is the explanation for a certain perennial freshness or news interest in subsequent adoptions of the plan. Persons not familiar with its early history have often assumed that coöperative education began at a different time and place, and the interest aroused by second-

[2] Vol. 1, p. 562.

(Continued on page 421)

ECONOMICS AND ENGINEERING EDUCATION *

By J. K. FINCH

Renwick Professor of Civil Engineering and Associate Dean, School of Engineering, Columbia University

Engineering education in the United States is now approaching the completion of its first century of service. Before 1850 there were only two engineering schools in this country. The great period of growth came just after the Civil War. By 1870 there were 70 such institutions. Today we have some 120 accredited engineering schools. When we look back over this century, certain outstanding trends in this remarkable growth are clear.

It is evident, for example, that the establishment of engineering schools paralleled the development of the modern scientific technique in engineering. The formal processes of the classroom and laboratory could replace, in part, the older, informal education through apprenticeship, only when the technique of engineering design itself became formalized,—became, to a major extent, a rationalized science rather than a practical art. The modern engineering school was born of the epoch marking applied mechanics of Rankine, Weisbach and others—these schools were born when the ancient art of engineering was fertilized by the advances in the natural sciences of the last century and scientific engineering came into being.

It has been not only the profound effect of this evolution in engineering technique which has determined the immediate objectives of American engineering education during this century. The immediate result was, of course, a strong emphasis on the scientific tools of modern engineering—on mathematics, mechanics, and details of design procedure. But there has also been the pressing demand of the westward advance of our civilization—the unparalleled rapidity of our conquest of a continent of unparalleled natural resources. The cry was for men with at least a bit of practical engineering training—for the immediately useful type of young engineer. And, it might be remarked in passing, we are experiencing today, in response to war needs, this same impatient and pressing demand for a vocational rather than a truly professional type of training.

* Presented at the 50th annual meeting, S. P. E. E. (Engineering Economy), New York City, June 27–29, 1942.

As a result of this immediate need for men of special but narrow training, our engineering schools turned out thousands of useful citizens—young men who could serve as draftsmen, detailers, surveyors, inspectors, etc.—but our program of engineering education still suffers today from this narrow, purely vocational viewpoint, from a training which, although it served so well in meeting the immediate needs of earlier days, is no longer regarded as either adequate in scope or professional in character.

The inevitable reaction to this narrow technology—a word which I heartily detest—began some twenty-five years ago. During these twenty-five years we have had much discussion of the need for a broader, more liberal training of the young engineer. It has become obvious that the professional engineer must be intelligently vocal, must have some perspective of the relationships of his profession to modern life, and some vision of its potentialities and responsibilities.

How much have we accomplished in meeting this changing need in engineering education? A fair and frank analysis will, I am afraid, not reveal a very creditable performance.

Our engineering schools, it is true, have to their credit a most remarkable accomplishment in advancing the standards of technical analysis and design. These schools, as we have said, were born of the movement for science in engineering, and they have led and still lead in its evolution and development. Recall for a moment the outstanding names in technical theory, and you will note that the great majority have been teachers of engineering as well as pioneers of engineering science.

On the other hand, our schools have been very slow indeed in achieving this broadening and liberalizing of the educational process which we have so often discussed.

One of the basic subjects in this broader field is economics—not the old, rather remote and aimless political economics, but the basic economics of engineering practice and of modern life and industry. *This subject has occupied a leading position on every list of desirable subjects in a liberal engineering curriculum.* What have we done about it?

In general we have grudgingly and most reluctantly found an hour or two in our programs for a general course in economics and have permitted the economics department to use them. In short, we have washed our hands of all responsibility for this unwelcome stepchild, we pay little attention to the scope or content of the course given—How many of you, for example, even know the names of the instructors who give this subject to your students?—

and we make no attempt whatever to integrate this earlier study with our engineering teaching or to build upon it in presenting our engineering subjects. There are times, in fact, when we simply ignore this subject, but there are others when we seem to avoid it as we would avoid a pestilence. Why?

In the first place, our major interest is, of necessity, in the special technique which we teach, which *we* think is *the* most important subject in the engineering curriculum, and which we "know how to teach." This specialty is a definite thing in which we are competent, while of economics we know little and feel that it cannot really be taught in the classroom—it is one of those things which the student will get, so 'tis said, "after he graduates."

If we are really frank in this appraisal of our shortcomings, we are forced to admit that a major difficulty is due to the character of the subject—our lack of interest in it, our lack of knowledge of it, and our failure to give time and thought to it. There is an element of sheer mental laziness in the picture. We follow the easier, well worn path, and seek to blaze no new trails.

Thus it is far easier for us to handle the rationalized analysis of stresses and strengths which lead to definite quantitative results in design, than it is to develop teaching data and methods in a new field. Furthermore, economic problems cannot be solved by formulas or slide rule. Their study usually leads to qualitative findings only. Ability to handle such problems rests, in large measure, on a maturity of judgment and experience in "practical affairs"—values which are not achieved through classroom training.

I admit the difficulties of the problem but, in my opinion, the chief value of economics as a vehicle of engineering education lies in these very difficulties which have been urged against it.

I recognize, for example, that few graduate engineers will be called upon to handle major economic problems until they have added maturity and experience to their college training through several years of apprenticeship. We cannot, therefore, urge that important technical subjects—subjects which few students can acquire "on their own" without instruction and guidance—should be abandoned to make room in an already overcrowded curriculum for extended courses in economics. But this is no reason for ignoring this subject completely.

I realize also that economic analysis does require a maturity of ability seldom found in the undergraduate—but "What is the purpose of engineering education?" Certainly its final objective is not that of cramming the student's head with factual information. The fundamental objective of engineering education cannot differ

from that of education in general, namely, the training of the student to utilize such grey matter as God has given him in the most effective manner possible. The accomplishment of this end is measured not by his store of factual information but by the competence of his mental machinery—by his competence to meet and handle new problems, to excerise, as he gathers and adds to it, his judgment in engineering matters. Surely we are not, as educators, aiding in this process of maturing the engineering mind, if we deliberately ignore those engineering problems which cannot be compressed into sugar-coated pills of factual information. This is not education; it is pure parrot training.

I also wonder how many of us realize how vital and unescapable this element of judgment is in engineering practice. Yet the emphasis in engineering teaching is always on the quantitative answer—always on the application of formula and the result checked to the last decimal. Structural design, for example, is usually taught as a problem in pure technical accounting. Here is a truss, assume certain loads, compute the stresses, assume certain working stresses, design members and details. But, before we can analyze stresses, we must assume loads, and before we design we must assume working stresses. Loads, factors of safety, working stresses—these are all matters of balancing the pros and cons of current practice and of attempting to forecast future needs and requirements—of engineering judgment. How often do we discuss them with our students?

Furthermore, what is the impelling force that urges us on to greater and greater efforts in the rationalization of technical design? It is primarily economic. Wellington hit the nail on the head many years ago when he noted that it was not the desire of the engineer to safeguard human life that led to better bridge design, but the keen competitive struggle to secure more economical construction. The search for economy is the mainspring of engineering progress.

The engineering teacher may, of course, complain that teaching data for economics is not readily available. General texts like Grant's "Engineering Economics" are, however, at hand, and a determined search of engineering literature will turn up a wealth of special problems in special fields. Some of these we have gathered together in note form at Columbia for a brief course for our students in civil engineering. The teacher who is really interested will have little difficulty in finding a variety of interesting material on this subject.

Finally, I am not urging that economics be taught as a separate subject—all by itself—in the engineering curriculum. A brief,

introductory treatment does seem desirable but few economic problems can be divorced from their technical context. The teaching of the technical economics peculiar to engineering design must go along hand in hand with design. These problems are fundamental to design for they condition and control its scope and character.

I believe this observation also applies to the broader, more general problems of economics—the relationships of engineering to our industrial, political and social life. A sane public works policy, for example, will never be achieved so long as such policies are based on political strategy, opportunism and mob psychology. All the popular votes in the world will not develop any justification for many of the elaborately useless and ingeniously unprofitable public works of the last decade. Money wasted in so-called public works is money that could be used to raise the standards of life and living of all our people. The problem is basically an economic problem, basically an engineering-economic problem, for our standards of living can be raised only by improving the standards of our economic life. Sooner or later, our scale of living must be so adjusted that the proceeds of our economic order can pay the bills for our social improvements. This is a problem of engineering and of production.

The engineering profession has always been a dynamic and constantly expanding profession. If the future engineer is to be more than a mere technician, more than the hired agent of the private or political purse, he must stir himself—salvation will come from within, not from without. We must seek not to attach new and unrelated disciplines to our teaching but to extend our methods and techniques into new fields. The teaching of economics, the kind of economics in which the engineer is interested, cannot be delegated to some other department, and divorced from the teaching of engineering itself. If we have anything to offer the public, it must rest on our ability to apply our methods in new fields of wider and greater service. It is full time that we stopped talking about economics and engineering and began to apply ourselves to the problem—to meet our obligations and take advantage of our opportunities. If we delegate this task to others, we give over with it the determination of engineering policies, and the opportunities which are open to us for wider service and greater public recognition as professional men.

I am convinced that the engineering profession is at the crossroads. It is clear that technical progress— the scientific rationalization of design—will and must continue to occupy our major attention. If, however, we permit it to crowd out all efforts toward the

development and rationalization of economic analysis and design, we will soon cease to be a profession and will become simply a group of narrow technical specialists. We must choose either the narrow technical path and leave the problems of the economic adjustment of our labors to modern industrial and social needs to specialists in applied economics, or we must make this field our own by applying to it—by extending into it—those honest viewpoints and methods which have long served us so well. We cannot indefinitely delay this decision. Long before another century has passed, the choice will no longer exist. We will have become either a narrow technology or an awakened profession.

(*Continued from page 415*)

ary pioneering has sometimes obscured the original work of the founder. Full credit should be given for later contributions, which have been many and important. At the same time, all honor is due to the one man who could ethically have claimed a basic patent on the coöperative idea. Whatever impression may have been gained by the magazine-reading public, the facts are well known in most educational circles. Among those who are best informed, Herman Schneider is given credit, not only for an epoch-making achievement but also for modesty in allowing his work to speak for itself.

THE EFFECT OF THE ESMDT PROGRAM UPON ESTABLISHED EVENING ENGINEERING CURRICULA *

By H. P. DUTTON

Illinois Institute of Technology

The Engineering, Science, and Management War Training courses offered by the Government to increase the national production are being conducted, for the most part, by the colleges and frequently are at least potentially in direct competition with regular evening classes. An inquiry as to the probable effects of the program on the long-time evening programs of the school is appropriate. It would be difficult on the basis of the short experience available to evaluate these effects with precision. Instead, I have attempted to appraise the effects at Illinois Institute of Technology, where some 14,000 men have taken advantage of the defense program to date. I have also secured expressions of opinion from other schools affected, and, finally, through the kindness of Professor John I. Yellott, Director of our War Training Courses, have secured a cross section of the preparation and plans of those now in our courses.

A first question might be as to the immediate budgetary effects of the courses. The Government's financial arrangements are well known and need not be elaborated upon. The effect on attendance in regular evening classes is the first question. Our own experience has been that the direct effect of the defense courses on attendance has so far been slight. These courses, as I believe is generally the case, do not carry college credit nor do they, for the most part, fit into plans of study for the usual Bachelor's Degree in Engineering. Students with the degree as an objective have in most cases gone on with their regular programs. We have felt the competition in courses nearly parallel, such as those given in Time Study and Metallurgy, for example. There has been little evidence of much competition in the basic courses so far.

On the other hand, consider the effect of introducing thousands of young men to the idea of evening study. We obtained something of a sample of the possibilities of this publicity through the

* Presented at the joint meeting of the Committee on Instructional Methods and the Committee on Evening Engineering Courses, S. P. E. E., Columbia University, June, 1942.

questionnaire to enrollees in ESMDT courses. Of 898 students who replied, 53 per cent stated that they had not previously attended any evening classes. 42 per cent had had no college work. 83 per cent planned to continue evening college classes when the defense program ends; 9 per cent did not; and 8 per cent were undecided or did not answer. 55 per cent were interested in earning a degree by evening study as against 30 per cent who were not. 3 per cent intended to study for the graduate degree, and 12 per cent were undecided or did not answer

Whether all students who checked "yes" on the questionnaire will actually pay hard cash for something which they previously obtained for nothing is a question. It is probable that at least a portion of those that have been introduced to evening college study and found it useful will go on. Indeed we are already beginning to receive inquiries and registrations from people whose interest was awakened by the ESMDT courses

It is to be anticipated with the continuance of the ESMWT Program that the direct competition with the regular courses will be increased somewhat but this loss will, we believe, be more than offset in the long run Checking the opinions of other schools as to effects on attendance of the twenty-two from whom replies were received, 14 per cent had felt an increase in enrollment of regular evening classes; 36 per cent a decrease; 36 per cent no substantial effects; and 14 per cent did not reply to this question

As to the type of course most affected, 5 per cent noted a shift from arts to technical courses, 10 per cent, a reduction in attendance in preparatory, trade, and certificate courses; 27 per cent a reduction in engineering and science attendance, 5 per cent, a reduction in management; 5 per cent, a general reduction; and 48 per cent did not reply 27 per cent thought the reduction would increase as the program continued, 41 per cent did not; and 32 per cent did not answer 41 per cent said that interest in all-round education had increased; 27 per cent said that it had decreased; and 32 per cent did not answer. 68 per cent thought the long-time effects of the program would be beneficial; 18 per cent thought they would definitely be injurious, principally as encouraging the idea of getting an education free; 14 per cent did not answer

In addition to the direct effects on enrollment, other effects may be considered. We have found that the establishment of the ESMDT courses had many valuable by-products in establishing or making more close, contacts of the school with local industries. 63 per cent of the schools replying to the questionnaire found the same benefit; 27 per cent had not experienced it; and 10 per cent made no comment.

It was not possible under the existing war load to turn to our regular faculty for most of the number of instructors needed. We went to industry, turning for help to companies which we considered leaders in their fields. From them, or with their advice, we have secured the necessary instructors. Many of these men doubtless will no longer be available after the emergency, but some of them may later continue with us. In any case, it can do the school no harm to have awakened the interest of these men and their companies in the school. 36 per cent of the schools reporting found the ESMDT Program beneficial in opening new sources of qualified instructors; 46 per cent did not; and 18 per cent did not reply.

One of the results which may be hoped for from the stimulus of this new teaching problem is the development of new teaching methods. There seems to have been a general increase in the use of visual aids to education in ESMWT courses. Several schools reported a beneficial stimulus to the regular day instructors from teaching evening students. There should result from this new educational problem, the ESMWT, other innovations which will improve our educational methods. Perhaps we have even more to learn from the wholly unconventional, yet successful, teaching methods developed by the Training Within Industry group, another division of the War Training Program, who have compressed into ten hours of instruction for foremen a very adequate introduction to training technique. To the question as to whether improvements in teaching technique had resulted from the program or were likely to result, 45 per cent replied in the affirmative; 45 per cent doubtful or negative; and 10 per cent did not answer.

Some of the comments which resulted from the questionnaire to other schools are interesting. Several expressed the fear that having entered this educational field, the Government would be slow to retire from it when the emergency had passed. We cannot dismiss this possibility, yet I feel it is fortunate that the program was started in the schools. The work is being done almost wholly by colleges and under the direction of men of long experience in the colleges. While the ESMWT program is capturing the spotlight for the time being, and for some courses is providing a rather stiff competition for the regular programs, it is still all in the family, and the directors of regular evening classs can certainly do more for themselves and their schools by cooperating with and learning from the defense program than by ignoring it.

Two or three commented on the fact that the emergency program was supplying the needs of a group for which little has heretofore been done, the technician who does not need and perhaps is not capable of digesting all the basic fundamental courses thought

of as part of the standard engineering degree program, yet who needs a type of practical technical training not now fully supplied by the public schools or by any other important source which will enable him to understand machinery and processes. Certainly the War Training Program should serve to emphasize the need for practical or refresher courses which can be taken by employed adults without going through the whole long series of prerequisites conventionally required.

The profile of a typical ESMDT student group as revealed by our questionnaire at the Institute is interesting. Age varied from 23 to 33 years, 27 years being the average age, as compared with probably 23 for the average evening student. Some of the enrollees are, of course, impossible, but for the group as a whole, the courses seem to be reaching into a higher bracket of responsibility. This may not be a bad thing for the evening schools.

While men in the higher performance brackets are not limited to college classes for keeping their thinking up to date, the college is still one of the most efficient methods of teaching adults. But the methods most effective with the typical undergraduate, do not fit the older, more responsible man. We need to raise our sights a little to reach the older man as well as the youngster. The ESMWT program seems to be doing this.

A fear was expressed as to whether this wholesale, mass production of engineers and subengineers would not result in a glut of engineers after the war. Except for incidental refreshing of previously trained men and the awakening of interest in engineering, the ESMWT courses do not train engineers. Should emergency justify it, the same teaching mechanism might well be put into reverse to retrain the ESMWT crop of technicians for other needed occupations.

While prophecy is a risky business, there is perhaps as much reason to expect better business after the war, if we win, as to expect a great depression. If this hope, held by many economists, is realized we shall not have too many engineers, and in any case we shall need the disciplined mind of the engineer. The ESMWT training is not to any great extent influencing directly the full-time undergraduate student's thinking about college; it touches the man already employed to the extent that this training program directly prepares him for more advanced work and awakens ambitions for further improvement. The national productive effort will gain, even if some of the specific skills developed by it for the emergency are in less demand after it has passed.

LIMITATIONS OF VISUAL EDUCATION*

By H J GILKEY

Iowa State College

It is the self imposed task of educators to process human progeny; to make of it a producing entity within a time allotment of some twenty years. The biologist, geneticist and psychologist tell us that our raw material remains about constant; that the aptitudes of the human infant undergo but slight change from generation to generation. The task of the classical educator is equally unchanging; languages and civilizations may die but the star of the classicist, far to the rear, is to him undimmed and he seeks not others. For the scientist it is not so. His horizon is ever broadening. Today the youth of twenty must be able to pick up and carry on from where an Einstein, an Edison or a Steinmetz had previously dropped in his own lustrous tracks after a lifetime of labored but brilliant advance

Add to necessity for comprehension, and manipulation (for these are the substance and techniques of the scientist), the requirements for design, construction and operation (all within the limitations set by sound economics), and you have before you the goal which is being currently attained by engineering educators. That we have thus far made good, part of the time at least, is no cause for resting on our laurels. We are indeed hard pressed as is attested by squeaks emanating from our engineering educational machine. Just what or how much is wrong is something upon which we seem unable to agree; certainly some of the noises are but the labored pantings of an engine under heavy load. Nevertheless, few of us will contend that our results are all that we would have them And the end is not yet; the generation just ahead is confronted with a task more formidable than ours for in science and engineering the future continues to pyramid on the past.

Under such circumstances it does indeed behoove the engineering educator to maintain a wary and vigilant eye upon every aspect of the mechanism he operates and to keep his oil can at hand. While the task of the engineering educator is too vital to admit of such drastic, visionary or irresponsible experimentation as is often urged upon us (usually but not always by persons without the profession), we need, nevertheless, to maintain an open mind along

* Presented at the 50th annual meeting, S. P. E. E. (Instructional Methods), New York City, June 27–29, 1942.

with the initiative and the courage to keep up with the best that we know. It is one of the primary functions of the Society and the specific function of this committee, on behalf of the Society, to seek out, investigate and make recommendations regarding anything that offers promise of assisting the engineering educator to discharge his obligation to the rising generation and to the profession with increased effectiveness. The program of this session has been dedicated to the task of subjecting to added scrutiny one of the most appealing of current potential innovations in our field. Virtually paralleling in its development and importance the motor driven vehicle, the photographic art, in all its ramifications and adaptations, may well have something of conspicuous value to contribute to our engineering educational processes.

In the field of learning the primary approaches to the mind are the eye and the ear. The visual processes include reading, demonstration and pictures but the term visual education normally refers to some form of pictorial presentation which may be animated or still; sound or silent. Under the commercial stimulus of the motion picture industry on the one hand and the ingenuity of the amateur and the exacting requirements of the scientist on the other, the variety of pictorial adaptations is great, ranging from ordinary still photography to the portrayal of animation, slow motion, time lapse, photomicrography, and miniature photography for all of which both the 35 and 16 or even the 8 mm. film can be used.

In a paper presented under the auspices of this committee,* the scheduled discussor of this presentation, George E. Tomlinson, reviewed the status of visual education, outlined problems relating to suitability and availability of material and offered constructive suggestions for overcoming existing problems of these types. He closed with the recommendation that a committee be created to report, among other things, answers to the following questions:

1. Is the use of selected motion picture films recommended as an aid to engineering teaching?

2. What films, suitable for use in engineering curricula, are available?

3. What is the attitude of independent and industrial producers towards coöperation in such a movement?

4. Should the selected film be collected in some central library or should the interested schools be referred to the numerous existing distributors?

5. Should selected reading and test material be prepared by some central agency for use with each program?

* "Use of Motion Pictures in Engineering Education," ENGINEERING EDUCATION, Vol. XLVI, p. 739–744 (1938); also JOURNAL OF ENGINEERING EDUCATION, Vol. XXIX, No. 9 (May, 1939).

6. Will the leading engineering societies and national foundations lend any assistance to the establishment and maintenance of an engineering film library? If so, to what extent?

7. What will be the cost of an adequate program during the first year of operation and during subsequent years?

8. How can our Society coöperate best with other agencies in improving teaching technique through the use of motion pictures?

This excellent set of questions is timely, provided the answer to Question 1 is "yes"; otherwise Questions 2–8 drop from the picture. In a sense of course, the answer is "yes" since both the film and the slide have proved useful in some of the marginal or motivational courses and in connection with student professional activities including freshman lectures and junior-senior seminars. In the study of such subjects as engineering materials (especially as regards the manufacturing aspects) and in building construction, the moderate use of films and slides may add enough to the interest to justify such use although the time requirement for covering a given block of the work will usually be increased. For lecture demonstrations films are often valuable especially where motion is an essential element, as in illustrating hydraulic flow phenomena or in demonstrating a sequence of operations. I can see where visual methods might be used to supplement inspection trips and in times like these, when actual trips are out, pictures doubtless constitute the best available substitute. Of course the film, however good, is not an adequate substitute; the noise et al. are an essential part of what the student needs to experience. Well chosen films may, however, aid him to spot in advance some of the things that he is supposed to see, or to give an added significance to what he saw, leaving him less mystified and diverted by noises, shiny gadgets and whirling gears.

Unless the writer is mistaken these are not the types of uses which Mr. Tomlinson had in mind. The question which he doubtless wanted to raise and to which inferentially the answer in his own mind was "yes," was whether or not visual instruction can be made an important aid in the teaching of basic middle-of-the-road engineering subjects. Is it a tool having potentialities of a sort that can assist the engineering educator substantially in doing a better or a more complete job within the limitations of time and money at his disposal? The more I ponder the matter, the more dubious do I become. There are, of course, certain obvious difficulties some of which relate more to the state of the art than to its ultimate possibilities. Among these are:

(*a*) *Lack of Suitable Facilities.*—If the projector requires darkening of the room (which is always objectionable because of the

slumber problem) there is the question of proper ventilation and convenient darkening devices.

(*b*) *Difficulties of Overhead.*—The projector and/or the film or slides are rarely at the immediate and ready disposal of the instructor. Usually special arrangements must be made well in advance and often an operator or an assistant is required. Sometimes there must be a fireman or inspector on the job and there are likely to be incidental fees. Any device designed to fit into the everyday teaching picture functions under a severe handicap if the instructor must be free the period before and/or after the demonstration or if he is otherwise required to perform unusual or time-consuming operations to use it.

(*c*) *Question of Subject Matter.*—At present the available material appropriate for technical entertainment is excellent, on the increase, and embodies a considerable variety from which to choose. For specific technical instruction where every lick must be made to count there is little suitable material available and I fail to see much likelihood that the need can be met squarely, if at all, in other than restricted fields. In rare cases an instructor does, at the expense of much time and effort, work out supplementary visual material which may be quite effective in his own hands; rarely otherwise. Commercially prepared material may be more generally effective but rarely will the scope or type of coverage be just what is wanted.

(*d*) *Cost.*—Relative cost will always be a dominant question but in the development stage it should not be accorded the stellar role. If the thing is found to be otherwise good, there is always the possibility that merit may circumvent cost.

Most of the objectionable items enumerated thus far could conceivably be minimized if not eliminated through general use and through mechanical improvements in equipment and in auxiliary facilities. Even the problems of personnel and overhead could doubtless be solved. A solution for the question of subject matter does appear to be, perhaps, the most remote. What I consider to be the real drawback has not yet been mentioned.

Visual education is virtually one type of lecture system teaching. Engineering educators are, I believe, generally agreed that the lecture system simply is not adapted to driving home solid engineering substance in the way that the engineer must have and use it. (Fortunately, perhaps, we aren't required to pass upon the possible merit of the lecture system as a serious educational tool in fields other than engineering.) Earlier in this discussion the ears and the eyes were mentioned as being the main entrances to the mind. Unfortunately, sometimes (fortunately at others), all that passes over a threshold does not take up its abode within that dwelling.

The retention of solid technical material is not attained through the eye or the ear unless there is subsequent study and mulling over until the material has been fitted into the mosaic of the mind and literally becomes an experience. The student may gain much of lasting solid benefit from a "heavy" lecture only if, after he takes careful notes, he studies these notes and assimilates their essential content. For many persons (not all) the eye constitutes a more effective initial entrance than does the ear but it is simply not possible to take notes from the screen in a manner that enables one to subject the substance, piecemeal, to the digestive juices of the mind or to apply the precepts and principles to the solution of appropriate problems.

Thus, as the writer sees it, the use of visual education for teaching basic work is open to the same objections as is the lecture system with the added difficulty that the student cannot secure the equivalent of an outline transcription for subsequent reiteration and assimilation. Important as this aspect is, it is not the only one of what might be termed the insurmountables or incompatibles.

The use of the projector erects a barrier between the mind of the instructor and that of his students. I believe that few engineering educators would contend that it is a primary function of the classroom contact to impart knowledge. What the student learns, he must in large measure dig out for himself. During the class period the instructor will probably clear up some difficulties but these are not stereotyped or predictable; if they were, the author of the text would have anticipated them in his treatment. Moreover, the best answers are invariably questions; there must be a give and take, the back and forth interchange that finally results in the student thinking through his question and answering it himself.

When the student is viewing a film, watching a demonstration, or listening to a dissertation, however fine it may be, his mind is relatively passive. The machine is his assurance of protection against a sudden and perhaps mildly disconcerting but stimulating mental jab. "He prepareth before me a table in the presence of mine enemies" (inquisitor; disturber of my peace). In whatever degree the visual demonstration constitutes an exposition or elucidation of essentially textual material, to that extent it is usurping the important and needed function of the study period where the student must learn to interpret the printed word; to translate it into the pattern of his thought and understanding. Just as, after graduation, his substance won't be brought to him on a silver platter, his thinking won't be done for him on a silvered screen.

If the film presentation is informational rather than expositional, it is not the sort of thing we are discussing for there is little place

down the middle of the engineering road for that which is purely or largely informational. Such material is marginal rather than basic and as such it does occupy a needed place in the engineering picture; out near the edges.

The writer believes that in view of the ever increasing tempo of engineering advance, the engineering educator must be on his toes to take advantage of every trustworthy (and sea-worthy) advance in the art of teaching. He can ill afford, however, to improvise where he ought to analyze; he must not become an educational boondoggler. In the field of engineering education visual methods now serve a limited but useful function. There is not, however, in the current picture as the writer sees it, justification for the belief that such methods offer prospects of being the medium for materially improving or speeding up the job. Besides various practical difficulties inherent in the state of the art, rather than in the art, he seriously doubts that such methods can be made to supply the sort of exposure and classroom contact that is needed to drive home basic engineering work.

PURE AND APPLIED MATHEMATICS *

By RUFUS OLDENBURGER

Professor of Mathematics, Illinois Institute of Technology

For the past fifty years American mathematicians have been primarily interested in pure, rather than applied, mathematics. Undoubtedly mathematics has its roots in the need of man to cope better with his surroundings. Certainly early mathematics was immediately tied up with applications. But after mathematics had attained some measure of maturity and had revealed a structure of its own, the connection between problems and applications became less intimate and new problems were attacked out of sheer scientific curiosity in an effort to build up the mathematical domain itself rather than to solve some immediate physical problem for practical reasons. With this evolution, two contrasting attitudes toward mathematical research were inevitably produced, the so-called "pure" mathematics school, concerned with the solution of problems which arise in the body of mathematics itself and the so-called "applied" mathematics school concerned with problems encountered in physical situations.

The position of the pure mathematician needs no justification since an investigation of the major branches of mathematics developed during the last few hundred years affirms that much of mathematics was introduced because some investigators were driven by curiosity about pure mathematics to explore these fields. Thus Gottfried Leibnitz (1646–1716) was led to his discovery of the calculus through geometrical considerations, Niels Abel (1802–1829) and Evariste Galois (1811–1832) founded the theory of Abelian functions and the Galois theory of equations respectively, brought to these theories by a sole and intense interest in mathematics itself.

It is also true that certain important developments in pure mathematics had their origin in applications. Thus there is the potential function which was introduced into applied mathematics by Joseph LaGrange (1736–1813) and extensively treated by mathematical physicists long before it was taken over by Georg Riemann (1826–1866) into pure mathematics. Also functions, such as Bessel (1784–1846) functions and Legendre (1752–1833)

* Presented at the 50th annual meeting, S. P. E. E., June 27–29, 1942, New York City.

polynomials arose in the treatment of physical problems and led to the study of the class of harmonic functions in pure mathematics. From this it is maintained that investigations in applied mathematics can be justfied on a purely academic basis.

A shunning of the applied has not always been prevalent among mathematicians here. On the contrary, the leading early Americans were chiefly of this category. Nathaniel Bowditch (1773–1838) published a book on navigation, as well as a paper on the pendulum. Benjamin Pierce (1809–1880) wrote a treatise on mechanics, besides contributing to the theory of linear associative algebras. George Hill (1838–1914) and Simon Newcomb (1835–1909), 3rd and 4th presidents, respectively, of the American Mathematical Society, were both astronomers of considerable reputation and contributors to certain phases of pure mathematics. Josiah Willard Gibbs (1839–1903), claimed by more than one branch of the applied sciences, made fundamental discoveries in thermodynamics and statistical mechanics. The second president of the American Mathematical Society, John Emory McClintock (1840–1916) was an actuary with the Mutual Life Insurance Company, whereas the fifth, Robert Simpson Woodward (1849–1924) specialized in astronomy and geodetics. These men were the leading American figures in the mathematical world before the foundation of the first important school of mathematics in this country at the University of Chicago in 1892, with Eliakim Hastings Moore (1862–1932), Heinrich Maschke (1853–1908) and Oskar Bolza (1857–) as professors.

It was this school that was largely responsible in influencing the research trends of subsequent American mathematics. From here were graduated the students who later aided in founding such great mathematical centers as those of Princeton and Harvard Universities. It is thus possible to trace the present general interest in pure mathematics to E. H. Moore, the leading American mathematician of his day. Moore, who had studied at the University of Berlin under Weierstrass (1815–1897) and Kronecker (1823–1891), both mathematicians of the pure variety, had been much influenced by them.

Although there has been a general apathy in this century in America toward the applied field, some of the most prominent of the present day mathematicians have made brief excursions into this realm. Gilbert A. Bliss, whose first paper was on astronomy, contributed to the theory of anti-aircraft guns during the first world war while working in the army ordinance section with Oswald Veblen. Veblen as well as Luther F. Eisenhart have done significant work in relativity. George D. Birkhoff has written papers on art and mathematical physics. Solomon Lefschetz started as an

electrical engineer, and after an industrial accident in 1907 began his brilliant researches in pure mathematics. Earl R. Hedrick wrote on the transmission of heat in boilers, and also on generalized forms of Hooke's Law. Norbert Wiener has written articles on electrical filtering, white light, and Brownian motion.

A few living American mathematicians have devoted themselves almost entirely to applied mathematics. Harry Bateman has contributed substantially to electromagnetics and hydrodynamics, F. D. Murnaghan and J. L. Synge to dynamics, elasticity, and relativity, H. P. Robertson and R. C. Tolman to relativity, while T. C. Fry has applied mathematics to the electrical industry. Some of these men are of the British school. However, an idea of the comparatively small activity in applied mathematics here can be obtained by an examination of the regular invited addresses given to the American Mathematical Society. In the period of April, 1921—April, 1938 there were 204 such addresses of which 36 were in applied mathematics. Of these, only 9 can be classed as of the engineering variety.

European mathematicians have always shown a keen interest in applications. The work and influence of Isaac Newton (1642–1727) in this direction was tremendous. Leonhard Euler (1707–1783) established the general equation of hydrodynamics. Joseph LaGrange introduced the least action principle into mechanics. Rudolph Clebsch (1833–1872) wrote the basic book on elasticity theory. Augustin Cauchy (1789–1857) remarkably enough devoted himself to all of the major fields of both pure and applied mathematics. Carl Gauss (1777–1855) was particularly active in geodetics and astronomy. Felix Klein (1849–1925) contributed to structural analysis, relativity and mechanics. Henri Poincaré (1854–1912) published results on the mathematics of the steam engine, and wrote an important paper (1907) on the magnetic energy in alternating systems. David Hilbert (1862–) was interested in mathematical physics although his work in this field did not have an influence to be compared with his significant developments in the various branches of pure mathematics. This is by no means an exhaustive list of the European giants, excluding in particular such men as Galois and Abel. Since a number of great mathematicians, such as Euler and Hilbert, turned to applied mathematics only late in life, it is not unreasonable to suppose that Galois and Abel might also have made significant contributions in applied mathematics had they but lived a normal span. Thus it has been that in Europe pure and applied mathematics have advanced hand in hand.

With the recent influx of the finest of European mathematicians, interest in the applied field has received a new impetus. Hermann

Weyl, John Von Neumann, Richard Courant and Albert Einstein are some of the men who have stimulated the American scene.

In speaking of applied mathematics it is advisable to distinguish between two schools into which this field can be divided. The one is the school of mathematical physics, concerned with the establishment of general relations between physical phenomena, whereas the other is the school of engineering mathematics focusing its attention on special problems which arise in the various branches of engineering. An example of this is the problem in aeronautical engineering of the lift of an airplane wing, with special attention given to the practical possibilities of the solution.

The field of engineering mathematics made noteworthy progress in Europe near the end of the last century after the visit of Felix Klein to the 1893 Chicago World's Fair. Klein was so much impressed by the raw materials, energy, and mechanical developments in this country that upon his return to Europe, so short of raw materials, in an effort to help her maintain her industrial position, he organized at Göttingen a school of applied mathematics and mechanics with the emphasis on engineering mathematics. T. Von Kármán and S. Timoshenko, whose influence on modern engineering has been tremendous, were products of this school. Flying in the early days was in the hands of inventors and craftsmen, whereas the Göttingen group evolved the necessary theory, and since there was no large body of conservative engineers to resist new methods, this branch developed rapidly and has profoundly influenced hydraulics and structural analysis. Von Kármán and Timoshenko are now in this country, and are known as engineers rather than mathematicians. Also claimed by the engineers are such Americans as Joseph Slepian, who has done excellent work on electrical arcs, L. A. Hazeltine, who invented the neutrodyne circuit of radio, and Thornton Fry, mentioned before, who has done considerable work on telephone exchanges and long distance communications.

With the advent of the second world war there has been a natural growth of interest in applied problems. The first school of engineering mathematics in this country was founded in 1941 at Brown University, receiving support from the U. S. Office of education, and the Carnegie Corporation of New York, as well as the University. It is a significant indication of the dearth of American trained applied mathematicians to know that the faculty of this school has been composed entirely of European trained men. It is fortunate that such men as Richard Von Mises, Willy Prager, Willy Feller, Hans and Eric Reissner, Kurt Friedrichs, and others have been available.

There is as yet no journal of applied mathematics in this country although there is a serious need for one. The Journal of Mathe-

matics and Physics has been largely devoted to this field but has been primarily an outlet for the publications of the faculty at the Massachusetts Institute of Technology. The founding of the Journal of Applied Mechanics has been of some assistance while the Physical Review has published a great many papers in mathematical physics, but there is still a real demand for a journal on a level between the mathematics journals and those of the physicists and engineers, one which would accept papers with a style not so severe as that required by the mathematical journals, and with applied features not quite so practical as those demanded by the engineering journals. Such a journal would do much to strengthen the position of applied mathematicians.

Not only has applied mathematics been neglected academically but industry has not had the policy of employing mathematicians as such. With the exception of a handful of the largest corporations who recognize their value, the position of mathematicians in industry has been analogous to that of the physicists of but a few years ago. At that time industrial problems which could have been best treated by physicists were turned over to men in other fields. The recent decided change in this situation has been largely due to the founding of the American Institute of Physics in 1931 with Henry A. Barton as its full time director. This institute has had an important influence in the promotion of industrial physicists with the result that the present reception of physicists by industry is incomparably more enthusiastic than that of mathematicians.

To educate industry to the use of mathematicians it is necessary that those employed label themselves mathematicians. It is necessary also that they become more familiar with the various branches of engineering so as to be fully equipped to attack engineering problems. Since the average engineer has had relatively little training in mathematics, he is not in a position to abstract a problem to a point where the mathematician can begin work on it. Therefore, to serve industry, mathematicians must know enough of the fundamental laws of elasticity or electrical networks, for example, to be able to transform a problem into mathematical terms from the physical situation. They should also be familiar with the various methods of measuring physical constants and be able to carry out or at least supervise experimental work.

Engineering schools are in an ideal position to train applied mathematicians. Here, because of the close association of mathematicians with their engineering colleagues the development of the applied field can best be fostered. The beginnings made at Brown University in this direction should be extended. Students should be encouraged to obtain the doctorate in applied mathematics and in addition to a thorough program in pure mathematics, courses in

such subjects as elasticity, plasticity, hydrodynamics, aerodynamics, electrical networks, electrodynamics, and thermodynamics should be offered. Such a program would be considerably aided by the publication of a textbook on engineering mathematics which would not only state leading engineering problems in mathematical terms, but would show the origin of the mathematical formulation. In view of these circumstances it is clearly possible for the professors of mathematics in the engineering schools to play an enviable role in bringing applied mathematics into a justly important position in this country.

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TEACHING METHODS AND COURSE CONTENT OF "INTRODUCTION TO ENGINEERING" AT RUTGERS UNIVERSITY*

By G. A. OLSEN

Purpose and Conduct of Course

During the summer of 1941 Rutgers University conducted, as part of its elaborate program of national defense training in New Jersey, a course in "Introduction to Engineering" for recent high school graduates. The course was designed to meet the pressing need for technical assistants, draftsmen, junior machinists, etc., required by the many nearby industries laboring heavily under large national defense contracts. Included in its curricula were studies in engineering problems, metallurgy and metal processing and engineering drawing. It is the purpose of this paper to discuss the methods of presentation and course content of the first of these three, engineering problems, to analyze it in the light of similar courses given in the regular college curricula and present certain conclusions from these analyses. The eighty students who took this course came from twenty-three different communities, some located as many as 45 miles from New Brunswick. With but a few exceptions, they had just graduated from high school. Some weeding action took place prior to their acceptance but this was only of the very superficial kind. All had comparatively good high school records, but as will be shown later, there were many below college caliber.

Course of Study

Sometime previous to the commencement date, there was planned a tentative outline of the course to be followed. This outline provided a rather slow but thorough program of study. It was a step in the dark as most proposed outlines must be where the background of the students is not fully known. The speaker and his colleagues soon found out that the proposed outline was entirely inadequate. Some students grasped the significance of the subject matter very quickly—others failed utterly. Some students who had obtained good grades in mathematics now showed themselves to be woefully weak. There were too many of this type to

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show that they had suffered a sudden reversal of form. Startling "mathematical revelations" proved beyond a doubt that their preparation for the intended course was poor.

In order to keep the better students interested and have those less prepared dwell on fundamentals, it was necessary to divide the students into four groups, A, B, C, and D. Whereas previously every student followed the same program, now two separate programs were instituted—the more advanced for A and B and the less advanced for C and D. It was interesting to note how effectively the separation was consummated. At the end of the first week the students were given a fairly simple examination covering mensuration and practical computations. The grades obtained for this quiz were used almost entirely in affecting the separation. As the work of the two separate programs progressed it was seen that with a possible exception of one or two cases, the division had been correctly made.

It was the more advanced program that the speaker was privileged to teach and all remarks hereafter made will refer to groups A and B alone. Out of a total of 44 hours a week in school, 20 hours were devoted to engineering problems. These hours were arranged in groups of four held either in the morning or afternoon on five days of the week. Groups A and B alternated in engineering problems on Thursday and Friday, respectively. The Saturday morning hours were devoted to a review and an examination of the week's work. Time for supervised study was made necessary due to the stipulation of those in authority that no outside work should be required.

Presentation of Subject Matter

The groups of four hours were, as initially proposed, broken down in order of—one hour of lecture, two hours of supervised study and one hour of review. In groups A and B it was felt that the hour for review was not essential and should be substituted with an additional lecture on a topic, interesting and if possible relevant to the subject studied in the preceding study period. The part-time instructor gave the lecture at this hour. One of the most pleasing things concerning the four-hour session was its flexibility. There were times when the lectures overran the hour allotted. There were also times when the supervised study periods were allowed to run over the two hours initially proposed. Whenever these changes were made, it was felt that they were made to the advantage of the student. For example, on June 23 the students were handling their slide rules for the first time and were especially interested. At the end of the supervised study period their fasci-

nation was undiminished and their need for additional dexterity still wanting. To have disturbed this critical concentration period would have been unwise and they were allowed to continue working problems to the end of the four-hour period.

The main lecture, given as has already been indicated at the beginning of the four-hour session, covered as thoroughly as possible only those topics intended for the supervised study period. In the speaker's opinion, time taken to cover topics in lecture which are not followed by problem work in the very next study period is largely wasted. It was also considered wise to review at the beginning of the lecture the work of the previous day. This was dovetailed into the advanced work as the lecture proceeded and helped to overcome the lack of orientation in thought evidenced by some students. This state of mind was probably caused by the lack of outside preparation.

Groups A and B were separated during the supervised study period. One assistant instructor was assigned to each group under the supervision of the instructor in charge. The latter traveled from one group to the other assisting in clearing vague points and supervising the study. The work performed during the study period consisted of problems taken from the textbooks and special problems assigned whenever additional work seemed advisable. A sufficient number of problems was assigned to keep the average student continuously busy during the two-hour session. Care was taken not to assign an overabundance of work. If, in the event, a student finished before the allotted time, he was the recipient of a few words of praise and an additional problem or two to keep him occupied for the remainder of the period. The flexibility of this method of assignments afforded an opportunity to:

1. Give a large number of problems.
2. Vary the difficulty of the problems assigned.
3. Adjust the number of problems assigned.
4. Provide advanced students with difficult problems.
5. Clear up immediately isolated points of difficulty.

In the course of the supervised study period, caution was taken not to answer questions directly until after a sufficient number of "provocative thought raisers" had failed to produce the desired result. This Socratic method of answering questions led to the belief that the students were building a logic of their own. It was also noted at first that certain students lacked the confidence to accept their own results as correct. This particular method seemed to dispel their fears. It was interesting to note that these fears seemed empty in face of the improved logic.

To one who had never had occasion to acquaint himself with supervised study, the attentiveness of the students to their work during these periods was amazing. Would that all our regular college students would concentrate as well!! *Due to the decrease in waste motion, it was observed that the work accomplished by an average student in two hours was equal to, and in many instances greater than, two outside assignments given in regular day school.*

The question is sometimes raised as to whether or not the student would be better off trying to puzzle out the answer to his own questions. While the speaker would not minimize the benefits of this method, he believes the efficiency of it is low. If the ability to solve problems is any indication of a person's command of a subject it should prove quite conclusively that the inclusion of a supervised study period is an excellent means of attaining this facility in a shorter time. But, the question is again raised—"does it not make him a mental weakling, dependent on others for assistance?" It might if the course did not consist of the manipulation of principles rather than of arbitrary facts. Inasmuch as the course emphasized the handling of fundamentals and problems different from those solved in class were given on frequent examinations, this objection should not be seriously considered.

Fourth Hour Lecture

The fourth hour lecture was introduced as a means of awakening interest in an advanced, related or parallel field. This step was taken when it was noticed that the students were usually tiring of solving problems at the end of the two-hour supervised study period. This extra "shot in the arm" served to prevent the stalling which would have occurred had the two-hour problem period been lengthened to three hours. The topics covered were briefly reviewed in the next regular lecture and problems assigned served to fix the material more definitely in the students' minds. While some of the students found it difficult to focus their entire attention upon the instructor for the duration of the lecture, it must be said to his credit that without the addition of these fourth-hour lectures the amount of work would have been substantially reduced.

Reviews and Examinations

During the first hour on Saturday mornings a review was given of the topics covered during the preceding week. Principles were emphasized and simple problems served as illustrations. No involved discussions were attempted.

The weekly examination followed immediately after the review period. In the beginning of the course open book examinations

were held. In order to provide greater mental development these were eliminated in favor of examinations where no assistance of any kind was given. In the opinion of the boys, it made them work harder, they were compelled to pay greater attention to the lectures and they developed a greater confidence and ability in their work.

The thoroughness of the examination made possible by the three hours available soon proved to be an excellent means of detecting weak points. The weekly examinations were intended to take about two hours to complete. This allowed the students an additional hour, if necessary, to complete the quiz. It had been initially proposed to use this last hour of the morning for a review of the quiz. This, however, seemed to be an anti-climax and was eliminated in favor of the additional time granted to slow students.

The weekly examinations were marked by the three assistant instructors. Due to the installation of a rotational system, each student received the benefit of the judgment of all three assistants.

Degree of Learning

Trying to compare the grades of the students in this "Introduction to Engineering" course with grades attained by regular college students is not an easy task. The difficulties are many. However, the opportunity of frequent and thorough examinations, graded and checked by four different people provided grades which in the opinions of those responsible were as representative of educational levels as was possible to produce. These grades together with an intimate knowledge of the students who obtained them have served to crystallize the opinion of the speaker for the comparison about to be made.

Contrasting the degree of learning of the college students the writer has been privileged to teach with that of the students in this summer course, it is not difficult after an analysis of the grades and abilities of each student to derive two surprising conclusions. The first is that the students in the summer course knew their subject as well as, if not better, than the regular college students, and second, there was a smaller range between the best and poorest student, indicating a higher group efficiency.

The final examination was rather extensive in scope as it covered a smattering of mathematics, mechanics, kinetics and strength of materials. Due to the wide variety in course material and the lack of any thorough review either in or out of class, it was both gratifying and interesting to note the grades obtained.

Let us analyze those for Group A—that group most closely approximating college material. The average of the grades was

75 per cent. Separating the grades into groups we obtain the following classification:

100%-90%—3
90%-80%—6
80%-70%—3
70%-60%—5
60%-50%—2.

These grades do not, in the speaker's opinion, indicate any poorer results than would be obtained in any other similar college group. It might possibly exceed them. For this reason, it is believed that these students proved themselves to have learned as much and possibly more than an average college student. It is to be remembered also that these students were under other disadvantages such as summer heat, 44 hours of school work a week, no vacation period prior to entrance from high school, and in many cases long commuting distances.

Time Comparisons

In these trying days, the subject of time has served as conversation for many lips. Time is no less important in the classroom these days than in the factory. And yet, in the light of the time consumed in the teaching of our lecture courses, are we availing ourselves of the most efficient method of "putting across" that which we have to teach? Let us look at a few facts.

The subject of mechanics has its roots in many college courses. The elements are first attacked in the regular Physics course where in most instances a half of a semester is devoted to this subject. Then again it is not unusual to find a freshman orientation course devoting some, if not all, of its time to the elementary principles of mechanics. Further, in the sophomore year a more formal course is usually given covering the two phases of mechanics, statics and kinetics.

A tabulation of the maximum and minimum number of hours usually devoted in these courses to topics covered in the "Introduction to Engineering" course shows the following:

	Min.	Max.
General Physics—7.5 weeks at 6 hrs./week (Includes laboratory)	45	45
Freshman Course—15 weeks at 3 hrs./week	0	45
Sophomore Statics	10	15
Sophomore Kinetics	12	16
	67	121

(Does not include outside assignments)

These same topics covered in the "Introduction to Engineering" course required the following number of hours of lecture and supervised study:

Statics	40
Kinetics	31
Total	71

(No outside assignments required)

This comparison, while perhaps a little rough, due to the wide variety of courses and techniques, nevertheless shows that mechanics can be taught more efficiently by the supervised study method and will produce as good students, if not better, than those subjected to pure lecture courses. These comparisons have been made with other subjects taught in this introductory program and the results have indicated the same trend as shown before.

Comparison of Teaching Loads

Here lies the inherent criticism of the supervised study plan. There never has seemed to be any question concerning the greater number of instructional hours required. And yet, few figures are available showing just how much more time will have to be spent by the instructor. Let us analyze this situation by using again the same subjects of statics and kinetics appearing in the previous paragraphs. The maximum and minimum teaching load in the regular college courses required to teach the topics covered in the introductory course is as follows:

	Hours	
	Instructor	Assistant
General Physics	45	24
Freshman Course	0– 45	0
Sophomore Statics	10– 15	0
Sophomore Kinetics	12– 16	0
	67–115	24

The teaching load required in the "Introduction to Engineering" course to cover these same topics is as follows:

	Hours	
	Instructor	Assistant
Statics	40	18
Kinetics	31	16
	71	34

These figures would indicate that the number of hours of teaching load for the instructor is approximately the same for both set-ups when the college courses require the minimum number of

hours. But as the number of courses involving the study of mechanics increases, the advantage lies with the combined course taught by the supervised study method. Under this plan the required assistant would, however, be on hand a greater number of hours. Whether or not the small difference here is significant is an open question. Surely the supposed great difference in teaching load would not exist if the various courses teaching mechanics could be grouped together under one main course.

Conclusions

There is an old Latin proverb, "Repetitio Mater Educato Est" which when translated into English infers that repetition is the sure way to learn a subject. This is undoubtedly true. But the question arises, "How much repetition is desirable in a college curriculum to enable the student to continue his studies in a profitable manner?" Is it necessary, for instance, for a student to repeat the subject of Statics two or three times before he is prepared to take a course in Strength of Materials? The speaker finds it hard to believe that this type of repetition is necessary. He believes that students in engineering need not take more than the one Mechanics course using the supervised study method before commencing further advanced studies. Whatever repetition is necessary will be obtained with the solution of a greater number of problems in class and with problems in the succeeding advanced courses.

This last thought provokes still another argument. Should the supervised study plan be adopted for all engineering courses? The speaker believes that the advantages of this method would suffer if it were adopted for courses other than the basic service courses. It is his belief that no advanced subject can be thoroughly mastered without considerable self-study.

No attempt has been made to suggest how a course of this type and layout could be fitted into the program of an institution operating at near capacity at the present time. This difficulty is unique and calls for an individual solution. If, however, a program has benefits such as accrued from the methods adopted in the "Introduction to Engineering" course at Rutgers, the speaker feels that its adoption into the curricula of our universities and colleges should be seriously considered even at this time.

The writer wishes to express his indebtedness to his colleague Mr. Sylvan Fich who delivered the fourth hour lectures and helped crystallize much of the thought in this paper.

SURVEY OF TYPE AND CONTENT OF COURSE MATERIAL IN MECHANICAL ENGINEERING LABORATORY INSTRUCTION *

By FRANK L. SCHWARTZ

Assistant Professor of Mechanical Engineering, University of Michigan

Questionnaires were sent to thirty-three schools and replies were received from 91 per cent of the schools canvassed. The survey covers twenty per cent of the engineering schools and forty-five per cent of the students of engineering schools in the United States.

At the annual meeting held at Pennsylvania State College in 1939, Professor Elliott of Wisconsin presented a paper, "A Survey of Heat Power Engineering Courses in the United States." Professor Elliott's paper dealt primarily with classroom instruction and heat power texts. The purpose of the present survey is to consider laboratory instruction for mechanical engineering students, particularly heat power laboratory instruction. Also, it would be of interest and value to compare the course content at intervals of say, ten years. Some of the experiments recently added to laboratory courses include heat transfer, fluid flow, metallography, and mechanical vibrations. As industry changes because of new developments, new courses are added to the curriculum, or at least the content of older courses is changed. These changes should apply to laboratory courses as well as to classroom courses.

The data have been tabulated on the accompanying chart. The number of clock hours assigned to mechanical engineering laboratory varies considerably in a range of 90 to 320 hours, with an average of 203 hours. Relatively few schools offer additional laboratory courses as electives. The number of required courses varies from 2 to 5. The credit hours allowed for the required courses ranged from 2 to 20. However, since there is not a standard definition of a credit hour, the number of credit hours allowed for required mechanical engineering laboratory courses has little significance.

The number of students per instructor varies from 5 to 38, with an average of 14.6. Over half of the colleges canvassed require complete reports on all experiments performed and, with two excep-

* Presented at the fiftieth annual meeting, S. P. E. E. (Mechanical Engineering), New York City, June 27–29, 1942.

Mechanical Engineering Laboratory Survey	Alabama P. I.	Case School App. Sci.	Cincinnati, Univ. of	Cornell Univ.	Georgia Sch. of Tech.	Ill., Univ. of	Iowa, Univ. of	Iowa State College	Kansas State College	Lehigh Univ.	Mass. Inst. Tech.	Michigan, Univ. of	N. Y., College of City	N. Y. U.	Northeastern Univ.	Northwestern T. I.	Ohio State Univ.	Okla. A. & M.	Okla., Univ. of	Penn. State	Pratt Inst.	Purdue Univ.	Rensselaer P. I.	Texas A. & M.	Va. P. I.	Wash., Univ. of	Wis., Univ. of	
1 General Information																												
1 No. of clock hours req'd of ME students	156	198	250	240	256	256	210	156	240	180	210	240	90	138	100	108	250	144	320	315	576	192	175	128	270	240	168	
2 No. of clock hours elective—ME students	0	0	0	0	0	0	0	70	0	195		72	0	0	35	72		0	0	0	0		0	0	0	0	0	
3 No. of courses for ME—required	4	5	3	4	4	2	2	5	5	4	2	2	2	4	3	3	5	3		4	5	3	2	2	5	4	4	
4 No. of courses for ME—elective	0	2	0	0	0	0	2	2	0	2		1	0	0	1	2	1	0		0	0	0	0	0	0	0	6	
5 No. of students per instructor	10	7	30	38	20	12	12	8-12	10-20	9-12	5-7	12	16	5-10	13	10	6-12	20		10	16	7-15	12-15	30	22-8	15	12	
6 % of experiments requiring reports	100	75	65	100	100	100	100	80	80	100	20	30	100	100	90	100	100	100		90	100	85	100	100	75	50	100	
7 Does English Dept. read the reports?	No	No	Yes	No	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No	No		Yes	Yes	Yes	No	No	No	Yes	No	
8 Does English Dept. grade any reports?	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	No	
9 Are students urged to buy refer. book?	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No	Yes	Yes	No	Yes	Yes	No		No	Yes	No	No	Yes	Yes	Yes	No	
10 Are mimeographed sheets available?	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No		No	No	No	Yes	Yes	Yes	Yes	Yes	
11 Are laboratory manuals available?	Yes	Yes	Yes	No	No	No	Yes	No	No	Yes	No	No	No		Yes	Yes	No	Yes		Yes	Yes	Yes	Yes	No	No	No	Yes	
2 1 Instruments				1							1																	2
2 Curve Drawing																			1									1
3 Planimeters; Length, Area	1	3	1	1	1	1		1	½	1	1		1			1		1	1	2				1	1		1	17
4 Platform Scales and Hoists	1									1							1	1	1				1					6
5 Time and Speed		2	1			1							2										1					5
6 Power—Dynamometer	1	1	1			1	1		½				1	1		1	1	1					1	1		1	1	15
7 Thermometers	1	1			1	1							1			1	2		1					1	1	1		11
8 Pressure, Vacuum	2	3	1		1	1	1	1	½	1			1	1	1	1	1	1	1				1	1	1	1	1	21
9 Indicators, Indicator Springs		1	1			1	1	2	½				1		1	1	1	1	1	3		2	2	1	1	2	1	19
10 Gas, Water, Steam, Air Flow Measurements	1	3	1	1			1	1		2						2	2		3	3			3	4		1	1	15
11 Calorimeters	1	1	1		1	1	1		½	1	1		1	1	1	1	1	1	1	1		1		1			1	20
12 Orifice Type Flow Meter	1									1				1	1			1	1			1	1	1		1		10
13 Orifice Calibration	1									1	1	⅓									1							5
14 Pitot Tube						1					1						1						1					4
15 Venturimeter					1							⅓					1				½			1				5
16 Weirs	1				2						1	⅓			2		2				½			1				8
17 Anemometer	1	1			1					1											1							5

	Mechanical Engineering Laboratory Survey	Alabama P. I.	Case School App. Sci.	Cincinnati, Univ. of	Cornell Univ.	Georgia Sch. of Tech.	Ill., Univ. of	Iowa, Univ. of	Iowa State College	Kansas State College	Lehigh Univ.	Mass. Inst. Tech.	Michigan, Univ. of	N. Y., College of City	N. Y. U.	Northeastern Univ.	Northwestern T. I.	Ohio State Univ.	Okla. A. & M.	Okla., Univ. of	Penn. State	Pratt Inst.	Purdue Univ.	Rensselaer P. I.	Texas A. & M.	Va. P. I.	Wash., Univ. of	Wis., Univ. of	
3	PRIME MOVERS																												
1	Valve Setting—Corliss, Slide—Diagrams	2		1			1			1		2	2	2		2		1	2	3		1	4		2		2	2	16
2	Steam Engine—Economy, Inspection	2	2	2	1	1		1	2	1½	3	3	2	1		1	2	1	2	2	2	3	2	2	3		2	3	24
3	Corliss Engine Economy				1		1	1						2									1					1	6
4	Steam Turbine Efficiency		1	1	1	1	1	1	1		2	1	2	2	1	1	3	1	1		1	2	1	1	1			1	22
5	Gas Engine Efficiency	1	1	1	2	1	1			1½				1						2		1	1		1				12
6	Oil Engine Efficiency		1	1									1		1							1	1						6
7	Internal Comb. Engine Test (Auto.)	1	1	1	1		1	2	1	1	1	1			1	1	1	1	2	3	1	4	1	1	1	5		1	23
8	Diesel Engine Test	3	1		1	1	1		1	1	3	1	1		1	1	1	1	1			1		2	2	1	1	2	21
9	I. C. Engine Timing, Ignition, Pressure		1			1													1		1		1			1	1		7
10	Compression Ratio Test														1		1			2						1			4
4	POWER PLANT AUXILIARIES																												
1	Separators, Traps, Lubricators, etc.	1									1			1											1				4
2	Injector, Ejector						1	1	1			1	1	1		1	1					1		1	1				11
3	Centrifugal Pump	1		1	1	1	1	1			1	2	2		2	2		1		1	1	1	3	1	1			1	19
4	Steam Pump—Simplex, Duplex, Triplex					1	1	1				1		1		2		1			1	1	2	1	1				12
5	Air Compressor		1		1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	25
6	Condensers		2									1		1							1								4
7	Feedwater Analysis and Treatment			1		1														1								1	4
8	Boiler Test	1	1	1	1	1		1	1	1	1	1	1					1	1		1	1		1		1	1	1	19
9	Power Plant Test		3				1												1	2	1		1		1		1		8
5	HYDRAULICS																												
1	Pump Valve Study											1																	1
2	Pelton Water Wheel—Hydraulic Turbine	1			1							2	2			1								2					6
3	Nozzles												1									1							2
4	Fluid Flow, Pipe Friction		2		2	1			2			1										1	1						7
6	AIR CONDITIONING																												
1	Centrifugal Fan	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2			1	24
2	Wind Tunnel Studies							1	1												2								3
3	Vacuum Heating Pump					1				1										1									3
4	Friction of Duct and Fittings										1			1															2
5	Oil Fired Domestic Boiler									1					2						1					2			4
6	Stokers and Boiler						2																1						2
7	Unit Heater	1					1									2					1					1			5
8	Radiators and Convectors		1	1							1				1	1						1	1			1			8
9	Heating System—Vapor, Hot Water, Central															1							1						2
10	Heating and Humidification		1				1		1								1												4
11	Cooling and Dehumidification						1		1																				2
12	Air Conditioner		1		1	1				2		1				2	1	1				1							9
7	HEAT TRANSFER																												
1	Heat Measurement											16 hrs.		1							1								3
2	Heat Transfer—Unit Heater		1			1								1															3
3	Heat Transfer—Pipe Insulation		1			1								1	1							1							5
4	Heat Exchanger									1		1			1		1												4

Mechanical Engineering Laboratory Survey	Alabama P. I.	Case School App. Sci.	Cincinnati, Univ. of	Cornell Univ.	Georgia Sch. of Tech.	Ill., Univ. of	Iowa, Univ. of	Iowa State College	Kansas State College	Lehigh Univ.	Mass. Inst. Tech.	Michigan, Univ. of	N. Y., College of City	N. Y. U.	Northeastern Univ.	Northwestern T. I.	Ohio State Univ.	Okla. A. & M.	Okla., Univ. of	Penn. State	Pratt Inst.	Purdue Univ.	Rensselaer P. I.	Texas A. & M.	Va. P. I.	Wash., Univ. of	Wis., Univ. of	
8 REFRIGERATION																												
1 Compression Plant	1	2	1	1	1	1		1	1	1	1	1	1	1		1		1		1	2	1	1	1		1	1	22
2 Absorption Plant										1											1	1						3
9 FUELS																												
1 Heating Value of Coal	1		1	1	1			1							1	1		1		1			1		1		1	12
2 Heating Value of Gas and Gasoline			1	1	1		1	1	1	1						1		1		1			2	1	1		1	14
3 Proximate Analysis of Coal	1		1	1				1						1		1		1		1			1				1	10
4 Gas Analysis																		1								1		2
5 Physical Properties																	1	1							1			3
6 Explosive Mixture—Air and Gas																2						1						2
7 Gasoline Distillation and Vapor Pressure	1		1		1			1	¼					1				1		1								8
8 Octane Rating—C.F.R.														1			1	1			1					1		5
9 Diesel Rating—C.F.R.																	1											1
10 Flue Gas Analysis	1	1	1		1	1	1		½	1			1			1	1	1			1	1						14
10 OIL																												
1 Physical Properties	1	1	1	2	1		1							1	1		1			1	2		1		2		1	14
11 MECHANICS	2	1	1			5									1							1						6
12 MATERIALS	5		7	3											2		2				16							6
13 INSPECTION TRIPS										1						1	1										1	4
METALLOGRAPHY		Mt	Mt	ME					Shop	Mt	Mt$_o$		Ch$_o$	Ch	ME			Ch$_o$			ME		Mt	ME	Mt		Ch	
HYDRAULIC LAB. OR FLUID MECHANICS								ME	M	CE			CE	M	CE	P	ME	CE	ME$_o$			CE	ME			CE	CE	
STRENGTH OF MATERIALS LAB.	ME	M		ME		M		M	M	CE	ME	M	CE	CE		CE	ME	CE	M	M	ME	CE	M	CE	M	ME	M	
FUEL AND OIL LAB.					ME			ME				Ch	Ch$_o$						ME	ME				Ch$_o$				
REFRIGERATION LAB.	ME																											
INTERNAL COMB. ENGINE LAB.	ME				ME			ME			ME$_o$	ME$_o$	ME		ME$_o$	ME	ME		ME									
MACHINE DES. LAB. OR VIBRATIONS					ME																P						ME	

ME—Mechanical Engineering. CE—Civil Engineering. Ch—Chemical Engineering. M—Applied Mechanics. P—Physics. Mt—Metallurgy. o—denotes elective or option.

tions, all schools require complete reports with at least 50 per cent of the experiments. In about ⅓ of the schools the English Department reads at least some of the reports. In only one school does the English Department grade the reports. In ½ of the colleges students are urged to secure a reference book. In all but two schools mimeographed notes or laboratory manuals are used and there seems to be little preference between notes or manuals. Several schools use both.

The course content varies within wide limits. The large variation of course content is influenced by such factors as available equipment, interests of instructors, specialization in certain fields at a given institution, type of school and allocation of theory courses among the several departments of a given school. The experiments have been listed on the chart under the headings: Instruments, Prime Movers, Power Plant Auxiliaries, Hydraulics, Air Conditioning, Heat Transfer, Refrigeration, Fuels, Oil, Mechanics, Materials. Many of the experiments could be classified under several headings. Certain experiments are combination experiments such as a combined test of a boiler and steam engine. Instruments is the second largest group of experiments. In some schools the study of instruments is made a part of an experiment wherein the instruments are used. Thus blank spaces in the instrument group do not necessarily indicate the particular instrument is not studied or calibrated. The largest group of tests is that involving the testing of prime movers with about as many tests of internal combustion engines as of steam engines and turbines. The principal tests of prime movers include: Valve Setting, Steam Engine Tests, Turbine Tests, Automotive Type Engines, Diesel Engines.

Of the Power Plant Auxiliaries group the most popular experiments are: Injector, Centrifugal Pump, Steam Pump, Air Compressor, Boiler Test.

At least half of the schools surveyed have separate hydraulic laboratory courses given by either the mechanical, civil, or applied mechanics department. Several schools seem not to give any laboratory work in hydraulics. A few schools include the study of hydraulic equipment in their heat power laboratory.

Most schools have included one or more experiments on air conditioning. If not dealing with cooling and dehumidification, experiments on domestic boilers, unit heaters or radiators are usually assigned. Some attempt has been made to include experiments involving heat transfer calculations, but the present survey shows that only a few experiments are assigned in only a few schools and the experiments appear to be rather elementary. Nearly all courses have an experiment on compression refrigeration, but few attempt experimental work on the absorption system or steam jet refrigera-

tion. Fuel testing is largely limited to determination of heating value of coal and gas, proximate analysis of coal and flue gas analysis. Apparently few laboratories are equipped with CFR (Cooperative Fuels Research) engines. Laboratory instruction on physical properties of oil is included in a majority of cases either in a heat power laboratory course or in a special fuel and oil laboratory course.

A list of experiments given at only one or two institutions includes: Curve Drawing, Determination of Clearance, Governors, Valve Gears, Locomotive Test, Triple Expansion Steam Engine, Boiler and Engine Test, Power Plant Study, Diesel Engine Timing, Radial Engine, Pulsometer, Rotary Pump, Superheater Test, Evaporators, Producer Gas Plant, Automatic Controls, Kohler Electric Light Plant. Hydraulic Ram, Automatic Ventilators, Heat Transfer Through Copper Tubing, Guarded Hot-Box Performance, Guarded Hot-Plate Performance, Fin Tube Coil, Fan Heating and Heating Systems, Vacuum Jet Refrigeration, Pressure-Temperature Characteristics of Liquid Fuels, Ash Fusion Temperature, Carbon Residue of Liquid Fuels, Screw Jack, Hoist, Electric Crane, Friction Drives, Belt Drives, Speed Reducer, Twist Drills, Railway Dynamometer Car, Railway Brake Shoes, Automotive Brake Tester, Vibration Analysis of Machine Bases, Pressure Temperature Relation of Steam, Psychrometric Tests, Adiabatic Saturation.

The data on the chart cannot be considered as complete. Some experiments might be given in other laboratory courses. This is particularly true with experiments on hydraulics, fuels and materials. No indication is given concerning the extent or time allotted for a given report.

At the bottom of the chart are tabulated seven laboratory courses other than heat power laboratory, with the departments in which they are taught. These data were obtained from college catalogues. A large variation in course names is to be found. These courses are listed under the names:

Metallography, Physical Metallurgy, Metals and Alloys, Metallurgy Laboratory.

Hydraulic Laboratory, Fluid Mechanics, Fluid Flow.

Strength of Materials Laboratory, Materials Laboratory, Engineering Materials Laboratory, Materials Testing, Mechanics of Materials, etc.

Fuels and Oil Laboratory, Fuels and Combustion, Engineering Chemistry.

Internal Combustion Engine Laboratory, Automotive Laboratory, Diesel Laboratory, Aero Laboratory.

Machine Design, Vibration Laboratory.

There is a wide variation in departments assigned to teach metallography, hydraulic laboratory, strength of materials laboratory, and fuels laboratory. Fifty per cent of the colleges in the survey are giving laboratory instruction in metallography. Hydraulics laboratory is also included in half of the schools as a separate course. Other schools include hydraulic experiments in mechanical engineering laboratory. Nearly all colleges have strength of materials laboratory given by either mechanical, civil, or mechanics dept. About ⅓ of the colleges have a separate laboratory for fuels and oils. A few schools are operating a laboratory in parallel with machine design courses. This is a relatively new development. These courses include photoelastic studies of fillets and similar stress concentrations, lubricating properties of oil, bearing tests, critical speeds, vibration isolation of machine bases, gyroscopic action, etc.

An average curriculum in mechanical engineering would contain three or four courses in mechanical engineering laboratory with a total of 200 clock hours. There would be approximately 15 students per instructor. Complete reports would be required for 85 per cent of the experiments. The English Department might be asked to read some of the reports but not to grade them. Instruction would be given by lecture and with the aid of a laboratory manual or mimeographed notes supplemented by reference books. About 29 experiments would be assigned and would include the following: Calorimeters, Steam Engine, two experiments, Steam Turbine, Internal Combusion Engine, two experiments, Diesel Engine, Air Compressor, Centrifugal Fan, Compression Refrigeration Plant. Seventy-five per cent of the courses contain the above tests. Other experiments would probably include tests or study of: Planimeters, Power Measurements, Dynamometer, Thermometers, Pressure and Vacuum gages, Manometers, Indicators, Indicator Springs, Gas, Water, Steam and Air Flow Measurements, Valve Setting, two experiments, Injector, Centrifugal Pump, Steam Pump, Boiler Test, Air Conditioner, Heating Value of Coal, Heating Value of Gas or Gasoline, Proximate Analysis of Coal, Flue Gas Analysis, Physical Properties of Oil.

What should be included in a laboratory course and how laboratory instruction can be made most effective are questions to which answers are usually given as opinions rather than facts. No one can accuse mechanical engineering laboratory instruction as being standardized. Perhaps engineering teachers of mechanical engineering laboratory are slow to develop new experiments and to revise old ones. One is always faced with the question of what should a laboratory course accomplish. Is the laboratory a place where

theoretical principles are tested; where the student becomes familiar with the latest and best equipment; where rudiments of testing and properties of materials are illustrated; where a student learns to plot data and write technical reports?

Many questions concerning mechanical engineering laboratory might be asked. A few are:

1. Is it desirable or necessary to have experimental work in the laboratory parallel classroom instruction?
2. Should all tests conform to A. S. M. E., A. S. T. M., S. A. E., etc., codes where codes are available?
3. Should students be required to use A. S. A. standard symbols?
4. Is it desirable to have a separate mechanical engineering laboratory department?
5. Should instructors of theory courses be required to teach some laboratory courses?
6. What experiments now given might be omitted?
7. How can some experiments be combined?
8. Is it desirable to assign a large number of experiments which are more or less specialized, or should a small number of experiments be set up which tie in several specialized tests?
9. Should the test of an air compressor be assigned before the testing of a steam engine?
10. What new experiments are highly desirable?
11. Should mechanical engineering teachers attempt to determine future needs of mechanical engineers and lay out laboratory courses to meet these needs, or should they wait until such demands are made by industry—*i.e.*, should the mechanical engineering laboratory instruction lead or follow the demands of industry?
12. Are mimeographed notes more desirable than laboratory manuals?
13. Should complete reports be required for all experiments?

SOME DESIGN PROBLEMS OF THE LIBERTY CARGO SHIPS*

By Henry C. E. Meyer

Of Gibbs and Cox, 1 Broadway, New York City

When I was asked to address you gentlemen I was given to understand that what I was supposed to talk about were certain engineering features in connection with War Work which might be of interest both from the engineering point of view, and from the practical production angle and also to see to it that they had some human interest values. Well, offhand I would say that there is very little you can touch upon in this war that is devoid of human interest as this struggle has become so widespread that each one of us is sorely affected by it in a thousand different ways.

While many may be inclined to disagree with me when I say that a state of war in the broad sense is not a normal condition for humanity to live in, since all life is a struggle, yet I feel that peace and war conditions of the body politic can rightly be compared with health and sickness of the corporeal body. And as the corporeal body reacts abnormally during severe illness, so too in wartimes we experience abnormal and contradictory conditions. In war we see sublime courage and devotion on the one hand and unspeakable cruelty and suffering on the other.

So on the one hand we have tremendous strides in advance in invention, on the other sheer necessity leads us to revert to practices and implements which were gradually falling into disuse. This leads me to a particular phase of wartime construction, namely, the type of machinery used in the so-called Liberty Ships and the sound reasons underlying its adoption.

While in the press we hear constant reports of how the shipbuilders are not producing enough ships, the fact remains that this particular type of ship is being completed in great numbers and while many more are still wanted and every effort should be made to expedite their building it still is true that a colossal accomplishment has been made already and when peace finally comes, as it assuredly will, these vessels will have had an important part in bringing it about.

Later on I propose to say a few things about what I believe to be some of the reasons underlying the fact that we are now desper-

* Presented at the 50th annual meeting, S. P. E. E. (M. E.), New York City, June 27–29, 1942.

ately trying to make up for lost time, but first I want to discuss the genesis of the Liberty Ships, which were an outgrowth of certain other ships ordered by the British Government.

In December, 1940 the British Government, faced with a constantly dwindling merchant fleet, decided to build sixty cargo vessels of roughly 10,000 tons deadweight, that is, cargo-carrying capacity, in this country and when they decided upon the type to be built they picked what is known as the North East Coast tramp. Now it happens that in the days of my youth I served an apprenticeship in one of the engine-building concerns on the northeast coast of England and later sailed in a typical tramp of this type, and hence this type of vessel had long been familiar to me and as a matter of fact was being remembered with a somewhat nostalgic interest. To anyone who has once sailed in the old reciprocating days, there never can be the romance in a turbine installation that there was in the old steam engine. I came across an old poem some time ago that expresses that feeling much better than I can and I will read it to you as it is short.

THE RECEEPROCATIN' MON

Oh! woesome 'oor that saw the birth
  O' turbine thochts in Parsons heid,
I weesh that I wis aff the earth
  Or else the turbine men wer' deid.
I'M a receeprocatin' mon,
  I luve tae hear the bearin' bump.
Or yet, the piston groan an' grunt
  that's religated tae a pump.

This whurligeein' thing I hate,
  For whatna guid is it tae dae?
Tae see the fearsome thing gyrate
  Gar's me puir stummick gang agley.

I widna care if it had ocht
  Tae need a tender fitter's hand,
But it rins sae weel sin' it was bocht
  I havna had to slack a gland.

I hate the tribe of whurligeegs,
  It's just a pinch o' steam, then scatt:
I'm a receeprocatin' mon
  I stan' or fa' wi' Jamie Watt.

Please do not take this too seriously as all seafaring people are such fearful liars. They are beefing every minute they are at sea about the hard lives they lead and how they wish they had a small corner grocery store at home with a liquor license attached, but let

them once reach that Utopia, from the moment they leave the sea until they pass in their checks they are telling all and sundry all about the romance of the sea, etc.

However, to return to our North East Coast tramp. This particular type of vessel, while it has for the last forty years carried the bulk of the world's cargoes, in some ways bears the same relation to a modern cargo carrier as the Model "T" Ford bears to a modern automobile.

We in America have developed cargo vessels fully the equal of anything abroad, and the British themselves have made considerable improvements in machinery for cargo vessels, so we felt somewhat surprised at the type of machinery selected, nay we were even dismayed as we were not at all sure that we could find today builders who could manufacture machinery of a type almost abandoned here. That the British had their misgivings as to our ability to deliver was also very evident, since they provided us with drawings of engines which did not represent their latest types, which use poppet valves for the H.P. and M.P. cylinders, but with drawings of an engine substantially identical with those built forty years ago. Another step which on the surface appeared to be backward was that the vessels were to be coal-burning, hand-fired, with Scotch boilers.

The use of coal which at first seemed surprising was however essential to the British as they were conserving their oil supply and in view of recent events we may come to regret some of our prodigality. Fortunately after we had become somewhat reluctantly reconciled to these decisions things began to happen. Two companies undertook to build shipyards with a promise to deliver the first ship in ten months. A builder who had built similar engines in the past undertook to build the engines. A manufacturer of locomotives undertook to build the Scotch boilers and so on and so on. As the plans supplied by Great Britain for the engines did not suit American Shop practices, the engine builders made new plans to cover points which in England are left to shop foremen and made the plans more readily adaptable for quantity production.

While all of this is still leading up to the "Liberty Ships" before reaching them I want to direct your attention to what to me have been minor miracles.

First, the engines were built and delivered on time and were excellent looking machines. Say what we will, they may have been of an almost obsolete design but there they were, and they are operating splendidly.

Second, the boilers about which I had many misgivings were the best looking Scotch boilers I have ever seen. Many years ago I specialized on the design of this type of boiler and when I looked

on these boilers, I could not help but feel that there had been a tremendous advance in the art of boiler making since last I was connected with it.

Third, the new yards *were* built and vessels *completed* with organizations that an orthodox shipbuilder would have considered as hopeless amateurs, and yet when I saw the first vessel in dry dock I could not help but admire the smooth-efficient manner in which the ship had been built.

Fourth, the first ship was delivered in October 1941, and on December 21, 1941 I was on board this vessel after it had made a fully loaded trip from the Pacific Coast through the Panama Canal to the East Coast.

Now, as I said before, strange things happen in war times, and to me who had for so many years dealt with nothing but oil burning vessels, this return to hand-fired, coal-burning was somewhat of a shock. To pass from an oil burning fire-room where everything is painted light or polished to a fire-room where hot coals are dragged out on the floor plates and extinguished with sea water each watch is a frightful contrast and one cannot help but be impressed by the fact that a hand-fired coal-burning ship is as dependent on the strength of man for its propulsion as was the ancient galley that was rowed by oars.

I have felt like a slave-driver myself many a time in the days when I used to run to the Gulf of Mexico and saw men collapse with fireman's cramps when trying to keep up steam. For anyone who has not a clear picture of what going to sea meant even in peace times under such conditions I commend McFee's book "Watch Below" which is the truest "picture" of that kind I have ever read.

Before finally leaving the subject of the British ships, there are several things I want you to note:

It is evident that their choice as to type was sound in that it ensured them having ships instead of promises of ships.

The ships present no operating problems to the British and I want here and now to express my admiration for these merchant crews who carry on under indescribable hardships, and certainly Churchill's words, "Sweat, Blood and Tears," applies to them.

Then the ships were and are being built on time and the British representatives here and abroad have not hesitated to praise the American builders and the quality of the ships.

In view of the results obtained there can now hardly be any question as to the wisdom of the decision by the British to stick to a simple type of vessel.

Shortly after the British Ships were contracted for the U. S. Maritime Commission decided to build a large number of what

were then called "Ugly Ducklings" but are now generally referred to as "Liberty Ships." I personally resented very much the name "Ugly Duckling" until one of my assistants drew my attention to the fact that in Hans Christian Anderson's immortal fairy tale, the "Ugly Duckling" turned into a swan. Well to a very large degree Hans Anderson's tale has come true, as not only are the ships good looking ships for their type but what is more important they are also being built and delivered and many are in service today. However, there lies behind this accomplishment a great deal of very hard work and a great many bold decisions.

First, while these ships are generally of a type similar to the British ships, many changes were made most important of which were the use of oil as fuel and water tube boilers instead of Scotch boilers. These two features were undoubtedly improvements, but the difficulty now arose that once started the tendency to change the design so as to "improve" it became almost an avalanche.

You gentlemen, who are interested in engineering education have a great responsibility as our future will depend more and more upon successful engineering, but I think you should give considerable attention to this tendency of ours to "improve" things. I will yield to no one, in my desire for advancement in engineering, or in my belief that when we stop progressing we die, but I have suffered a great deal in my career from "improvements" made mostly by others but also sometimes by myself.

Now, it can be imagined that when it was proposed to build very large numbers of American ships with machinery largely identical with that of a British type of cargo steamer when we had developed cargo vessels of a much higher type with much more modern machinery, it took a special set of circumstances and a special kind of courage to make the final decision. Unfortunately the special circumstances existed in the exigencies of war and thank God the courage was also there in the authorities who had the final say so.

This does not mean that there was not a great deal of argument from the bright and well meaning individuals who desired to rescue some of the machinery from the stigma of antiquated design. I say it took courage in the face of such criticisms to finally insist on duplication of the British machinery wherever possible, and again I repeat such courage was present in high places.

Now let me point out that had another course been followed the changes in minor details would have been legion, and while the ultimate result might have been a somewhat more efficient installation several other and most unpleasant things might have happened.

First, it has been my unfortunate experience in many cases that where an "improvement" is made in any piece of apparatus that

functions perfectly without this "improvement" we generally get into trouble. I have in mind a number of cases where certain apparatus had functioned properly for years, and when increased production was required other manufacturers were called upon to manufacture this apparatus from the original designs. As a matter of engineering pride the new manufacturers who were given the original designs made certain small apparently innocuous changes, which completely ditched the performance of the apparatus in question resulting in much loss of time and study to find in the end that the old features had to be restored.

Next, whenever changes of this type are made they usually involve a great many conferences, and then unless the changes are properly tested out before their adoption, one has the unpleasant experience of finding that when the entire plant is tested the performance is marred due to the failure of some very small detail. As a matter of fact I am always much more afraid of the results from the failure of the small inconsequential details than I am of the major problems in engineering. As an example of what I mean I can cite the following!

When after the last war the firm I am connected with reconditioned the *S.S. Leviathan* we found that the holds aft of the machinery spaces all drained into one common space namely, the shaft alleys, where there were cocks which were supposed to be closed in case of a collision. We did not believe this to be a safe arrangement for a passenger steamer so we isolated the various compartments by installing separate closed tanks for each compartment. Yet we found the entire scheme was nullified as the pipe fitters connected all of the vents from the tanks to a common line below the water line. Fortunately the mistake was discovered before the ship went into service.

In the machinery installations of the Liberty Ships in addition to the two principal changes mentioned before, there were many other more or less old-fashioned features and I will endeavor to enumerate the principal ones.

The vacuum was maintained by air pumps of the "EDWARDS" type driven by levers from the L.P. crossheads instead of by air ejectors and condensate pumps. The main feed pumps are of the vertical simplex reciprocating steam driven type. The main circulating pump is of the centrifugal type steam engine driven. The forced draft blower is of the multi-vane type driven by reciprocating steam engine. The generators are driven by reciprocating steam engines.

So you see all of these auxiliaries were of a type not very frequently built any more, and there was therefore quite a revival in the building of small reciprocating machinery.

When the Liberty Ship program got under way there were contracts made with about twelve engine builders who were all supplied with plans of the engines for the British ships. As stated before the first American manufacturer had redrawn and amplified the British plans to suit American practice. As soon as these plans were distributed the fun started all over again, as each manufacturer had practices that differed somewhat from the others, and correspondence about details took on such tremendous proportions that utter confusion would have resulted had not a conference between all of the engine manufacturers and the various interests been called to straighten out details. Two days of such a conference performed marvels. All of the difficulties were ironed out and from then on the progress was rapid with a minimum of questions arising. The cooperation of these engine builders with the various authorities and with each other was a most healthy example of what American unity can do when it wishes to really "go to town."

What worked in the case of the engines was equally effective in the case of the boilers, auxiliaries, deck machinery and other component parts of the vessel. This most cooperative effort bore splendid fruit.

I well remember the last World War when we also endeavored to build "a bridge of ships" as it was then called. I was connected with the American Bureau of Shipping at the time and got a very intimate view of the entire picture. Yards sprang up all over the country, and almost each yard designed a type of vessel of its own. Hence all of the yards competed with each other for the technicians available in the country and as shipbuilding had always been more or less a child of misfortune, that group of technicians was spread out pretty thin.

Then the various yards competed with each other in obtaining equipment and in general machinery designed for ships building in one yard could not be changed to another yard. From this resulted the condition that if a machinery builder failed to deliver on time the ship had to wait, or if the ship was late the engine would be left standing on the dock. In view of this confusion it was surprising that any ships were completed before the Armistice, and the painful fact is that of some two thousand ships ordered during the last war the very great majority were completed after the Armistice.

Thank God, some one had the foresight to avoid such a thing this time, and as a result today ships are building at many yards that are identical, and engines, boilers, shafting, propellers and auxiliaries are being swapped all over the country, ships which need engines, getting them on time whether they were the engines scheduled for them or not.

I mentioned a few moments ago the fact that some two thousand ships were built during and after the last war with great hopes for an American Merchant Marine. Where are all of these ships? Gentlemen the tragedy of it is that nearly all have gone to the scrap-yard, and unfortunately a great deal of that scrap has been used by Japan to make munitions to shoot back at us.

I said some time ago that I wanted to touch upon some of the reasons why we have been so unprepared as regards our maritime affairs.

If one reviews the history of the United States one finds that while we can exert tremendous efforts in the face of great stress to build both a merchant marine or a Navy, we become completely apathetic the minute the danger passes, and while we now promise ourselves that we will make this the greatest maritime nation in the world, we'll ship our goods in German and Japanese ships after the war is over if we don't make up our minds now, "That it shall not happen again."

Right at the present time there is naturally a great interest in the magnificent performance of our Navy and also everybody is keenly aware of the cry for more and more ships. But how many of us realize that between the end of the 1st World War and 1933 there was very little Naval construction of any kind, and that there were built only very few merchant ships for any purpose?

As mentioned before the speaker was interested in the reconstruction of the *Leviathan* after the 1st World War and while temporarily there seemed to be some interest on the part of the American public in American ships at the time this ship went into service, I heard many Americans say not long after, "Why should we travel on American ships where you can't get a drink?" Well, gentlemen, I never thought much of Prohibition, but I think it is pathetic that the patronage of many Americans went by preference to non-American passenger ships for the sake of a drink. As a matter of fact I doubt if some of the thirsty ones would have found it absolutely impossible to have their wants met even on American ships. This apathy of the public in maritime affairs is to a large extent responsible for the fact that we are now feverishly building up our Navy. Surely it cannot be blamed on the Navy as they have consistently begged and pleaded for a long range plan of building up the Naval Forces, but disarmament was in the air, and as was said many times "Public opinion would not stand for it."

Now, "Public opinion" is you and I and all political leaders are very sensitive to "Public opinion" and if enough will clamor for tax reduction the first thing to go will be appropriations for the armed forces. So, we have our choice right now.

When the war is over we can start yelling for reduction in armaments with the inevitable result that in some twenty years we will again be unprepared, and remember, the time element wherein we can "catch up" on the enemy is ever getting shorter, and the difficulties of getting started from scratch are ever getting greater as mechanical science becomes more complicated. On the other hand we can start now and resolve that come what may, we will oppose any move that will allow our armed forces to slump back into a condition where an enemy can prepare himself over a period of years to attack us when he feels he is good and ready. I am for disarmament of the "Enemy."

ESMWT—AN EXPERIMENT IN ENGINEERING EDUCATION *

By FRED W. OCVIRK

Cornell University

The ESMDT, now ESMWT, has been in force for over a year and a half, and there is no doubt that it will continue to be in force for sometime to come. No one actually knows how long it will endure, but we are faced with daring to think of the possibility that it may become a peacetime institution. However, whether it survives a long life or not, the ESMWT has been and still is an experiment which will leave its effect upon engineering education and may even reach into its peacetime policies. With the permission of this body, I should like to make some remarks about the possible trend in engineering education based upon observations made in the ESMWT program sponsored by Cornell University in Buffalo, N. Y.

The ESMWT has become a meeting ground for three important agencies, namely, the United States government, industry and the university. The fact that these agencies have been so closely united for the common interest of the people of the United States and for democracy indicates that the university has a large social obligation to fulfill. It is true that the university has always felt this obligation by ever broadening its dissemination of knowledge to a growing student body. Now, however, it has the impetus to broaden itself even more.

But how can the university better meet its responsibilities to industry and country if more is demanded of it? Surely the number of departments and branches in the engineering school has reached its saturation point. It is suggested here that this can be done not by adding more departments and branches but by offering training at a greater number of levels to individuals of various levels of intelligence and capabilities. The word "level" here is meant to be synonymous with the word "grade."

Industry has found that it can use trained personnel of many grades. For example, it has a place for the college graduate as well as for the graduate with advanced degrees, and it also has a place for the high school graduate. But in addition to these, it

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also has a great many places for personnel who should be trained between high school grade and college grade. Unfortunately, not enough men of such grade are available because not enough of such in-between training is available. To be sure, technical institutes and advanced vocational and technical high schools are providing training of this grade, but it appaers that this field of training is so broad as to make it necessary to call the university into it.

The ESMWT has to some measure provided the necessary filling for this gap by training the in-between type of engineering student. For example, in the ESMWT courses offered to the aircraft industries of Buffalo, Cornell University has been providing courses in aircraft structures which are of the three distinct levels indicated by "elementary, intermediate and advanced." The difference in the level of each course seems to be clearly defined by the theoretical and mathematical background that the student taking these courses is capable of absorbing. The "elementary" student, for example, is prepared to learn about aerodynamics and aircraft structures so long as the mathematics involved is no more difficult than algebra and trigonometry. The "intermediate" student is capable of understanding these same subjects with a background of higher mathematics such as the calculus so long as it is used in derivations but not in the so-called practical execution of problems of analysis and design. The third level of student, the "advanced" student, is of graduate caliber and is able to master the use of higher mathematics and apply it to such theories as elasticity and fluid mechanics.

The last named type of student trained in higher mathematics and in classical engineering is a type that the university looks upon as ideal; this is the type it wishes to turn out, but unfortunately, there is a limited number of this type. The great majority of students graduated are of the "intermediate" type. This is not meant to be a criticism since both of these types are necessary to industry, and the university is performing its function well in training such types.

However, the "elementary" student may be the one that we have neglected. He is the type of student that finds mathematics particularly difficult; he is the type that flunks calculus; he is the type that busts out of college at the end of the second year because he has reached the terminal point in his level of academic study. Yet this type of student can be well utilized in industry for lesser engineering jobs providing that he had a training of a so-called practical nature. This is the type of student that could be directed to undertake more than the usual amount of drafting, more than the usual amount of machine shop work, to take courses in

gauging and tooling, standard structural and routine chemical and metallurgical testing.

Just how the university can solve the "elementary" student's problem is not offered here, because it is not an easy problem to solve, but an effort is here made to emphasize the importance of this student's problem. Engineering educators have been considering this problem for some time so that it cannot be said to be a new one. It is here revived only because it has become of great importance in the industrial effort for the sake of the people of the United States.

Since the university is offering training to the "elementary" student through the channels of the ESMWT, I should like to tell of the training which Cornell University has been offering to this type of student for the benefit of the aircraft industries of Buffalo, N. Y. Of all of the courses offered in the Cornell brochure, the courses commanding the largest interest and the largest enrollment were the elementary ones. A great wave of students already employed in the aircraft plants, namely, Bell Aircraft Corporation and Curtiss-Wright Corporation, came to the courses to obtain a start in engineering. Most of these men had had only a high school training carrying them through algebra and trigonometry and high school chemistry and physics. Lesser jobs in engineering were to be had by these men if they could only secure a beginning education in engineering to fit them for the jobs.

Since the aircraft work done in Buffalo is that of manufacturing the structural parts of an airplane, it was necessary that Cornell offer courses to this elementary group in the understanding of forces and of materials in general as well as in the understanding of particular forces and particular materials of which aircraft structures are made.

Altogether four courses were taught these men, one a formal course in mechanics and strength of materials and three in elementary aircraft structures. The first course in formal mechanics, lasting thirty weeks, was presented with as many aircraft applications as it was possible to give. For example, in discussing the mechanical properties of materials, aircraft materials such as aluminum alloys and chromemolybdenum steels were emphasized, and such materials as concrete and stone were only briefly touched upon. The concept of safety factor and of margin of safety from the aircraft viewpoint were given. Column formulas as given by the government aircraft specifications manual ANC-5 were included. Riveted joints were studied using the small size aluminum alloy rivets ranging from a sixteenth of an inch to a quarter of an inch in diameter. Special emphasis was placed upon the fundamentals of longitudinal shear analysis which are so important

in aircraft stress analysis. An outstanding difference from the usual collegiate courses in mechanics was the fact that the course was presented as a combined one covering both mechanics and strength of materials as a mixture. For example, the simple stresses of tension, compression and shear were discussed at the outset together with the mechanical properties of materials. Next came a study of force systems and equilibrium. Then finally the theories of beams, columns and torsion were discussed.

The course was entirely devoid of the calculus so that geometrical and arithmetical proofs were substituted wherever possible. The beam stress formula, the torsional shear stress formula for circular sections and the area-moment method for beam deflections were derived in this manner. In two instances, however, the calculus is indispensible. The derivation of the specific formulas for the moment of inertia of given geometrical cross sections was not possible without the calculus although it could be shown that $bh^3/12$ held as the moment of inertia of a rectangular cross section by dividing the rectangular into small parts and summing up the second moments of all of the parts. Also in the derivation of Euler's long column formula the calculus was necessary, but since the students in the course were not prepared to digest such a derivation, the expressions for critical load of long columns were given point blank without derivation.

With the ground work laid in mechanics and strength of materials, the students were now ready for courses in elementary aircraft stress analysis. But what were we to offer them about aircraft structures? First, an introductory study had to be made of the loads which are peculiar to an aircraft. This meant that a study of aerodynamics was necessary since such loads were born of the dynamic qualities of the air.

Second, it was necessary to differentiate between the two main types of aircraft structures—those whose members were made of trusses and those which were made of thin shelled beams technically known as monocoque or stressed-skin structures. The first of these types is exemplified in early models of aircraft while the second of these is found in the newer all metal planes. Quite naturally, the students were interested in the latest types since such planes were in their hands at all times.

By coincidence the study of these two types of craft fall into the two divisions of structural mechanics. The trussed type employs primarily the principles of mechanics and the beam type of craft utilizes the tools of elasticity or strength of materials. With these natural divisions as a guide, we began our elementary aircraft structures course with the first type bearing the thought in mind of following it with the monocoque type. However, the ac-

tual beginning had to be made with a brief study of aerodynamics. But this study could not be of the formal kind since there was neither time nor necessity for studying it that way. Fortunately, the limited amount of aerodynamics that we were able to study yielded splendid problems in the use of mechanics.

For example, the aircraft in its entirety could be studied as a free body in which the four principal forces could be represented as resultant forces of weight, lift, drag and thrust. These same resultants were then to be studied as distributed forces which necessitated enough aerodynamics to indicate *how* they were distributed. Once this was accomplished it was possible to show in what manner the loads developed the stresses in the members of the four main parts of the aircraft structure, namely, the wing, the fuselage, the landing gear and the tail assembly.

Problems were then presented with the purpose in mind of illustrating the general stress distribution in each of these parts of an airplane. For example, a problem was given in the stress analysis of a wooden spar wing of a semicantilever monoplane in which the student was required to determine the bending and direct stresses in the spars; the direct stresses in the wing struts and in the drag struts and in the drag wires; and the shear stresses in the main connecting bolts. Another problem was that of determining the stresses in the members of a biplane truss; this was a particularly good problem since it embodied forces in space.

A landing gear problem in which the members were made of tubular sections was included in the course as another application of mechanics. So was also the problem in the analysis of a fuselage truss subjected to six loading conditions in flight and on the ground; the problem was extended to include the design of the members as chromemolybdenum tubes in which they were selected from column curves peculiar to the aircraft industry.

These problems were lengthy ones requiring as many as six and seven class periods in their execution. This provided an excellent opportunity to teach the men orderly organization of their work in neat report form. Neatness, good sketches, tables and organization of computations were emphasized. Graphical solutions of trusses were employed wherever possible, a useful method because of the lack of symmetry in such structures.

When it came time to study the second type of craft, it was found that the analysis of the all metal stressed-skin aircraft had to be taught differently since so much of the basic theory of strength of materials had to be reviewed and supplemented with extended theories. For example, such flexural problems as unsymmetrical bending had to be impressed on the minds of the students. In turn, the fundamentals of principal axes had to be stud-

ied. The formulas of bending shear also had to be rigidly reviewed since they were so vital to the understanding of stress distribution in thin-walled beams. This same study led to the concept of shear center or center of twist. In turn this led to shear distribution in thin-walled members in torsion. Difficulties arose since the students had studied shear stresses in the twisting of circular bars only; new theories had to be divulged to show the shear distribution in the twisting of open sections and of oddly shaped tubular sections. Unfortunately, the mathematics of the membrane analogy is difficult so that formulas were given point blank.

Once the concepts of unsymmetrical bending, bending and torsional shear were reviewed, they could be applied to cellular wing and fuselage sections. However, the applications were to unusually simple beam cross sections, and a warning had to be issued that the problems of everyday aircraft practice were ever so much more difficult.

At the completion of this course in monocoque structures it was decided that the courses in elementary aircraft structures should terminate because the problems about aircraft structures that could now be considered were no longer of an elementary nature. A further study of mathematics and a return to the fundamentals of advanced mechanics was necessary to continue.

One great danger faced the instructing staff in handling this group of men; it was that a man might get the idea that he was a finished engineer once he had completed his first course in mechanics and strength of materials. To combat this idea the men had to be impressed constantly that they had started something that would take a life time of study to complete if at all and that the training that we were offering them was the merest drop in the educational bucket. Now that a year and a half have passed, it can be safely said that this danger has never manifested itself. The reason for this may be largely in the fact that the student was told that some of the proofs of fundamental theorems were to be reserved for the future at such time as he had equipped himself with the proper mathematics. In this way the student realized his limitations and consequently was not able to adopt the wiseacre attitude.

It is interesting to note, however, that many of these "elementary" students took enough interest in mathematics to enroll in regular tuition courses in analytical geometry and the calculus offered by the University of Buffalo, and as a result they will be allowed to enter our regular collegiate "intermediate" courses in stress analysis.

It is also notable that the aircraft companies employing these men have made transfers, promotions and salary increases as a

result of the training the men received from these elementary courses. A number of the men employed as detail draftsmen or liaisson draftsmen have been transfered to the stress group. Other individuals employed in the machine shop or assembly shop were asked to come into the engineering department to do liaisson drafting or to work with the production planning group. Some shop men were transferred to the mold loft or to better jobs in the shop. Many of them remained at their regular jobs receiving promotions and salary increases.

In telling the story of our elementary courses in aircraft structures, it is meant here to indicate what can be done with the student whose mathematical training is limited to algebra and trigonometry. This student is capable of absorbing a large amount of practical applications which are not final in the academic sense but which are useful in some place in industry. Courses to train such a student may be a channel through which the university can better meet its obligation to industry and country.

In conclusion it is suggested here that the trend in educational policy should be to establish one set standard in the tone of its curriculum but to institute as well a graded set of levels of terminal training. Industry and country need men of varied degrees of training ranging from the most elementary to the most advanced, and it is the obligation of the university to train as many of these as possible. This means that we cannot neglect classical engineering because it has a vital place to fulfill; the aircraft industry, for example, is solving many of its most important theoretical problems in this level of study. At the same time we cannot neglect the empirical engineering because of its important practical function. This means also that students must be carefully preselected for the level of study to which they are best suited, the best students to study classical engineering and the others to study less academic engineering. This means that no student should be rejected from a university because he fails to achieve a given level; he should be directed into a curriculum at his own level. This may mean that if the student cannot come to the university, it should go to him through extension mediums.

THE EDUCATIONAL PROBLEM OF UNITS *

By ROBERT E. DOHERTY

President, Carnegie Institute of Technology

My plea is not for a particular system of units; rather it is for an adequate educational treatment of the subject of units. For as I understand it—or perhaps I should say, as I would have it—the educational problem now before the Committee on Physics of this Society is primarily one of building clear concepts and not merely one of memorizing names, numbers, and formulas. And I shall discuss the matter from this point of view.

In the first place, I wish to consider with you the relative values to the student's ultimate professional competence of these two different educational policies. In the one case the theory is that the student's intellectual efforts should be focused upon fundamental principles and the achievement of an elementary competence in their application to simple, physical situations; that the knowledge he is required to master be that, and only that, which is required for the clear understanding of those principles and for the achievement of that elementary competence in their application; and that in determining the extent of ground to be thus covered, the test and the guide should be sound understanding of what has been covered. The theory in the other case, at least a theory that fits the traditional facts, is that the student's work in physics should cover all grounds of fundamental knowledge that *might* relate to his subsequent work in engineering courses, his reading of scientific literature, and his later professional life. In the first theory, understanding takes precedence over ground covered; in the second, ground to be covered takes precedence over understanding.

Which of these theories, as applied to the problem of units, is likely to contribute more to the student's ultimate competence? I can think of no other educational front where such devastating confusion exists; nor yet one where understanding is more essential. Perhaps I should use the past tense, for I have neither taught any classes nor directly administered the work of young engineers for six or eight years. But assuming that no educational revolution has occurred during that interim, I may be justified in stating that

* Presented at the 50th annual meeting, S. P. E. E. (Physics), New York City, June 27–29, 1942.

conclusion. For many years I was intimately associated in technical work and education with large numbers of engineering graduates—mostly electrical and mechanical—from practically every engineering college in the country, and then for five years in addition with undergraduates in the classroom. This experience led me to my conviction in this matter, and I have stated it for what it may be worth in answering which theory is better. If the second theory—the cover-the-ground theory—represents the traditional policy, as I assume it does since it represents the practice, then the facts of my experience leave no doubt in my mind that this policy has demonstrated its ineffectiveness. Moreover, if ultimate professional competence rests upon clear understanding and clear thinking, as I assume it does, then again it would seem even less necessary to adduce such facts as I have observed in order to indicate that the cover-the-ground theory is ineffective. Procedures based on this theory, whether in physics or any other subject, lead to an habitual state of mind which I have called "complacency in confusion." By continued repetition of the process of covering assignments that are not understood, but are yet passed by the student so far as the instructor is concerned by temporarily memorizing words, formulas, and procedures, the student ultimately finds confusion to be a normal state of mind. I need not labor the point further. Clear understanding and an elementary competence in the application of the fundamental principles in units, as in anything else, is, I am sure you will agree, absolutely essential in the building of professional competence. And if so, it follows that that educational policy should be whole-heartedly pursued which will assure the achievement of such understanding and such competence.

So I start from this premise and have a few specific observations to make.

First, the severe limitations of time and the very nature of the learning process impose the following requirements: restriction of area to be covered, simplicity of approach, and the attaching of new growth of understanding to the roots of the student's personal experience.

These requirements indicate to me that the student in elementary physics should be expected *to study one system only.* Did you ever stop to calculate the amount of time in the physics program that can be devoted to units? If not, do so, and you will find a convincing reason for the one-system-only proposal; provided of course that you accept the premise here adopted. For to achieve the objectives indicated—understanding and elementary competence—there is more to do than learn names of units and some numbers that go with them; there are to be considered as well the

theory of units and dimensions, an understandable demonstration of their significance in the laboratory, and their elementary use throughout the course. It is probably too much to expect that sophomores will be equal to all of this in the time available, even for one system of units, let alone two, three, or four. But, it may be contended, he will think there is only one system, or that other systems are not as good. The simple answer to this is that in the proposed plan, he is to learn—he must learn—to use other systems and mixtures of systems in later courses and in practice. He can and should be told that there are these numerous other systems and that he will later have to learn how to use many of them, and mixtures of them, but that if he fully understands the theory of the one, he can easily understand the others; and he can be truthfully told too that if he does not understand the one, he won't understand any of the others. So I urge the study of only one system in elementary physics.

If one system were to be studied, what should that system be? I think this question is of much less importance than the ones already discussed, but certainly we have established at least some criteria for the selection. It should combine simplicity together with the possibility of the student's tapping to the greatest possible extent his directly perceived experience when trying to grasp the new concepts. Also it should encompass electrical quantities, since the student must study electricity in physics. His understanding is not facilitated by a system of units for which the examples are embellished unnecessarily by numerical factors such as 10^n, nor by one in which the unit of mass bears the same name as the unit of force in another system the student has heard about, nor yet by one in which the unit of force requires the student to become either a fly or a derrick in order to experience it directly. If these considerations point to any particular system more than to others it would seem to be the MKS system, in which the magnitudes of the quantities represented by these fundamental units are readily perceivable and conversion factors are reduced to a minimum. There may be some confusion between kilogram mass and kilogram weight, but at least the newton is not the magnitude of a force that equals the weight of any unit mass. And moreover the MKS system is beautifully adapted to electricity as studied in physics, or elsewhere; factors of 10^n are not required at the conclusion of a problem to convert the results to joules, watts, or amperes.

Then there is one more observation I would make. Understanding of other systems and competence in their use should be developed in later courses as a *continuation in the student's mind* from the concepts established in physics. This suggestion has extremely

important practical implications. It means a new plan of coordination of work in physics with that in departments of mechanics and engineering, for I take it that we should not be far wrong to assume that *effective* plans to this end in engineering schools today are few and far between. Yet it always seemed incredible to me that the plan of progress in engineering studies is set according to the personal notions and understanding of individual instructors instead of according to the understanding and continuous growth of understanding of the student, for whom after all the entire plan is intended. The later courses in engineering and mechanics should start with the concepts established in physics—including those of units—and help the student build as a continuous process upon those concepts; and it is important also to state the converse, namely, that discontinuities in intellectual growth should be avoided, and certainly also the confusion of terminology and ideas as between physics and later courses that today so greatly plague the student. For the result of this is negative; it has to be later undone, or else the student left in enduring confusion.

I am inclined reluctantly to make one provisional concession. I am quite aware of the argument that it is desirable to introduce at least two systems. Surely, as the argument runs, one should learn to deal with units related to the metric system, since they extend to the field of electricity, and yet it is not less important to learn the English practical system as well, both because the student is familiar with the terms and he will use them in mechanics. But the difficulty is that he would have to learn two systems instead of one in the limited time, and the advantage of starting with familiar terms—*e.g.*, pounds, feet—is partially offset by the inherent confusion as between pound mass and pound weight. But I grant that unless the course in mechanics starts at the point where physics leaves off in the matter of units as well as in other concepts, continuity is broken. Hence, if it is a practical fact that mechanics teachers have not yet reached a point where they feel prepared to help the student build his understanding continuously, starting from units based on the metric system and leading into the English system, and if there are equally compelling practical reasons, as I know there are, why physics teachers would not accept the English engineering system as the only system to be studied, then I would grudgingly concede the point provisionally and hope for a better day in the future. For a reduction of the number of systems to two in the near future would be a real step in the indicated direction.

Thus my plea is that it be the business of physics in connection with units, as with its other matters, to establish clear concepts and

an elementary competence in their use; that understanding take precedence over ground to be covered; that wherever it may be at present practically feasible, only one system of units be covered in physics, slight preference being for the MKS system, and that the principle of continuous growth in understanding be adopted requiring that progress in subsequent courses in mechanics and engineering stem continuously from the basic trunk established in physics.

COLLEGE NOTES

The fifth regional center of the Human Engineering Laboratory, offering non-profit services to residents of Ohio, Western Pennsylvania, lower Michigan, Indiana and states to the south, has been established at CASE SCHOOL OF APPLIED SCIENCE. The Human Engineering Laboratory is a clinical organization for the measurement of individual aptitudes and for career guidance on the professional and executive level. Founded by Dr. Johnson O'Connor, at Stevens Institute of Technology in 1922, the first center attained immediate success, resulting in the establishment of a second center at the Massachusetts Institute of Technology in Boston, a third at the Illinois Institute of Technology in Chicago, and a fourth at Chestnut Hill Academy near Philadelphia.

The Laboratory offers testing service to all persons nine years of age or older. Tests cover personality traits, structural visualization, accounting aptitude, tonal memory, creative imagination, English vocabulary, inductive reasoning and other critical factors in choosing scientific, professional and executive careers.

RECOMMENDATIONS TO THE WAR MANPOWER COMMISSION *

January 6, 1943

It is the opinion of the Consultative Committee on Engineering that the action announced by the War Manpower Commission on December 18, 1942, with respect to the deferment of engineering students, although solving certain important parts of the general problem of professional engineering manpower, falls short of what the immediate situation demands, and it is urged that the action be promptly reconsidered.

The action defers only such students as have successfully completed one year of college work. This Committee is convinced that, until reliable facts, now missing, are available and a rational plan based thereon is formulated by the War Manpower Commission for assuring the minimum supply of engineering personnel at professional level that is essential to national safety, the freshmen also should be deferred.

There are no obscure assumptions involved in this view. In such an important matter as maintaining technical superiority in the war, decisions and plans should be based on facts—not on official guesses, especially when this is unnecessary. The essential facts, not yet available as to actual needs of professional engineering personnel by industry in the tremendous war production program ahead, can be made available in a reasonable time, if the Committee's recommendation of December 8, 1942, is followed. Meantime the basic elements of the educational machinery that may be—and probably will be—found necessary in the face of facts, should not be demolished. It will take too long to rebuild it, if it is found to be necessary. If the teaching staff for freshmen is dispersed and the flow of students for industry is cut off, and then later both are found by the proposed survey to be required, an extra and unnecessary burden of delay and confusion will be imposed on the war effort.

(Presumably the armed forces have as much at stake as industry in an adequate supply of men well grounded and fully trained in fundamentals of science and engineering. The announced curricula of the Navy College Plan would seem to recognize this point.

* Recommendations to Dr. Edward C. Elliott, Division of Professional and Technical Training, War Manpower Commission, by the Consultative Committee on Engineering of the Division.

The curricula of the Army Specialist Training Corps are not yet announced. But these programs, we must assume, will assure a flow of students adequate in number and appropriately trained for each of the several branches of the armed services.)

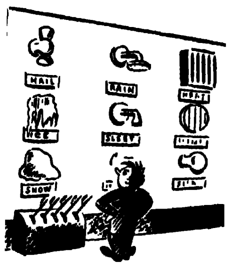
There may be good reasons, unknown to the Committee, why the W.M.C. did not accept its recommendation of this temporary expedient, but until the engineering profession, as represented in the Committee, understands such reasons it must press for recognition of its view. As a profession, engineers responsible for industrial production and technical superiority profess and claim responsibility in these matters, and claim as well a voice in plans in which they are expected to meet that responsibility.

The Committee does not accept as a valid reason for rejection of this plan of a *temporary expedient* the fact that a fraction of the freshman class in engineering (those not in the Enlisted Reserves) would be withheld from military training for three months or so. This number alongside the totals involved in this age group would seem insignificant, especially when it may be found that the fraction referred to is needed more for the war effort in industry than in the armed forces. Whether this is so or not can be determined by an intelligent survey in a reasonable time; it cannot be guessed.

The Committee therefore urges again that all engineering students subject to Selective Service and who are in good scholastic standing be deferred until the survey of facts is completed and a rational plan based thereon for training and distribution of professional engineering manpower is formulated by the War Manpower Commission.

R. E. DOHERTY, *Chairman*

G-E Campus News



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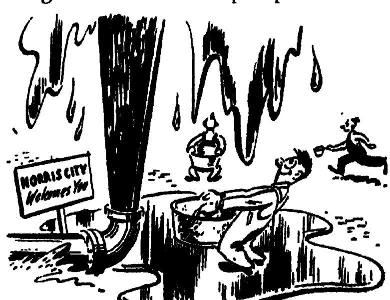

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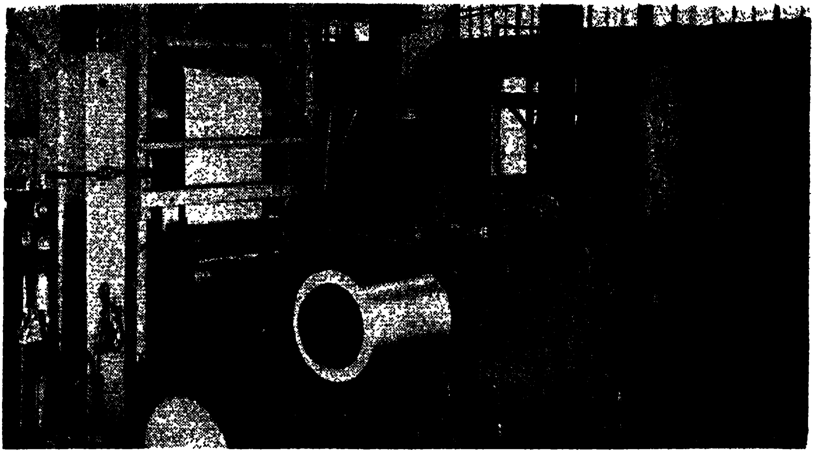

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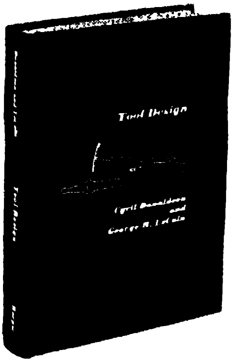

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ENROLLMENT OF UNDERGRADUATE ENGINEERING STUDENTS, AS OF OCTOBER 5, 1942*

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Aeronautical	1,794	1,284	941	719	98	4	4,840
Agricultural	135	107	81	60	—	8	391
Architectural	381	314	318	277	36	9	1,335
Ceramic	109	136	101	96	—	8	450
Chemical	4,639	4,018	3,191	2,450	261	132	14,691
Civil	3,221	2,598	2,046	1,590	52	146	9,653
Electrical	3,655	3,338	2,695	2,070	120	102	11,980
Industrial	503	485	419	448	19	9	1,883
Mechanical	7,596	6,724	5,145	4,043	296	84	23,888
Metallurgical	409	525	461	436	12	17	1,860
Mining	268	233	212	275	6	10	1,004
General	13,702	2,084	590	576	—	59	17,011
Others	468	324	300	246	1	119	1,458
Marine	29	82	55	45	—	4	215
Petroleum	375	297	228	246	—	11	1,157
Totals	37,284	22,549	16,783	13,577	923	722	91,838

* By mutual agreement with the Society and to avoid the filling out of another questionnaire, the enrollment of undergraduate engineering students was secured this year by the National Roster of Scientific and Specialized Personnel, Office for Emergency Management, War Manpower Commission, and submitted to the S.P.E.E. for publication. NOTE: Evening students are not included in the enrollment figures this year.—F. L. BISHOP, *Secretary*.

Enrollment of Undergraduate Engineering Students, 1942–43—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Akron	111	51	33	34	29	—	258
Ala. Poly	607	375	297	257	—	—	1,536
Ala. Uni	366	251	179	176	—	—	972
Alfred	55	52	38	33	—	3	181
Arizona	168	93	73	56	—	7	397
Arkansas	262	86	79	34	—	—	461
Bradley	66	42	17	6	—	—	131
Brooklyn	207	219	177	146	—	12	761
Brown	150	70	51	40	—	—	311
Bucknell	112	85	64	43	—	—	304
Calif. Tech	—	—	—	—	—	—	—
Calif. Uni	—	—	—	—	—	—	—
Calif. Uni. So	128	112	141	103	—	15	499
Carnegie	416	282	259	282	—	—	1,239
Case	308	258	236	181	—	—	983
Catholic	69	51	44	41	—	—	205
Cincinnati	549	304	226	180	200	13	1,472
Citadel	160	114	47	41	—	—	362
Clarkson	269	140	99	97	—	—	605
Clemson	—	—	—	—	—	—	—
Colo. Mines	218	175	127	120	—	—	640
Colo. State	139	64	53	35	—	—	291
Colo. Univ	—	—	—	—	—	—	—
Columbia	—	—	—	—	—	—	—
Connecticut	225	129	67	36	—	—	457

Enrollment of Undergraduate Engineering Students, 1942–43—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Cooper	123	98	58	55	—	—	334
Cornell	645	435	276	234	27	32	1,649
Dayton	115	40	35	26	—	—	216
Delaware	112	69	45	36	—	4	266
Denver	56	44	13	17	—	—	130
Detroit	303	135	148	80	84	1	751
Drexel	521	230	255	89	—	3	1,098
Duke	145	85	52	39	—	3	324
Fenn	108	98	91	45	49	—	391
Florida	300	150	75	72	—	—	597
Geo. Wash. Uni.	—	—	—	—	—	—	—
Ga. Sch. Tech.	721	696	629	368	—	5	2,419
Gonzaga	81	40	34	17	—	5	172
Harvard	—	61	62	34	—	26	183
Haverford	16	11	7	9	—	—	43
Howard	50	13	6	8	—	—	77
Idaho	235	94	57	45	—	—	431
Ill. Tech.	902	488	383	294	86	67	2,220
Illinois Uni.	1,123	465	538	414	—	—	2,540
Iowa St. Coll.	944	599	370	313	1	21	2,248
Iowa. Uni.	191	118	90	82	—	—	481
Johns Hopkins	131	106	90	65	—	41	433

Enrollment of Undergraduate Engineering Students, 1942–43—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Kansas St. Coll.	420	232	187	124	—	—	963
Kansas Uni.	244	186	144	120	—	4	698
Kentucky	166	127	73	47	—	—	413
Lafayette	197	214	117	99	—	—	627
Lehigh	480	276	183	177	—	3	1,119
La. Poly.	136	96	55	41	—	—	328
La. So. W.	111	77	37	23	—	—	248
Louisiana U.	—	—	—	—	—	—	—
Louisville	145	76	62	56	—	2	341
Maine	277	172	148	104	—	11	712
Manhattan	188	137	69	50	—	—	444
Marquette	300	175	146	127	82	3	833
Maryland	395	148	124	80	1	—	748
Mass. Inst. Tech.	—	—	—	—	—	—	—
Mich. Mines	—	—	—	—	—	—	—
Mich. St. Coll.	458	247	181	188	—	—	1,074
Mich. Uni.	741	643	478	365	—	—	2,227
Minnesota	659	517	455	450	—	—	2,081
Miss. St. Coll.	—	—	—	—	—	—	—
Miss. Univ.	49	16	15	14	—	—	94
*Missouri Mines	258	176	206	213	—	27	880
Missouri Univ.	306	178	129	108	—	—	721
Mont. Mines	45	48	42	33	12	4	184
Mont. St. Coll.	200	161	82	79	—	—	522

Enrollment of Undergraduate Engineering Students, 1942–43—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Nebraska	444	196	124	77		2	843
Newark	264	241	148	142	—	1	796
New Hampshire	230	125	83	91	—	—	529
N. Mex. A. & M.	86	36	24	21	—	—	167
N. Mex. Mines	27	19	20	18	—	—	84
N. Mex. Univ.	99	67	37	30	6	—	239
New York City Coll.	1,296	714	457	315	—	—	2,782
New York Univ.	303	304	250	214	—	59	1,130
N. Car. St. Coll.	—	—	—	—	—	—	—
N. Dak. Agr.	—	—	—	—	—	—	—
N. Dak. Uni.	110	57	39	27	—	36	269
Northeastern	570	425	268	209	195	—	1,667
Northwestern	350	199	135	75	—	—	759
Norwich	97	80	48	28	—	—	253
Notre Dame	298	176	116	99	—	—	689
Ohio No. Univ.	61	30	22	28	—	1	142
Ohio St. Univ.	921	518	359	331	—	48	2,177
Okla. A. & M.	453	241	167	136	4	1	1,002
Okla. Univ.	463	334	280	221	—	—	1,298
Oregon	595	259	156	158	—	1	1,169
Pa. St. Coll.	827	549	405	317	—	21	2,119
Pa. Uni.	172	117	78	58	—	—	425
Pittsburgh	338	249	204	213	—	—	1,004
Porto Rico	159	104	97	39	40	—	439
Pratt	123	178	117	104	—	—	522

Enrollment of Undergraduate Engineering Students, 1942–43—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Princeton	204	160	98	88	2	13	565
Purdue	1,612	919	670	622	—	8	3,831
Rensselaer	519	349	294	278	—	29	1,469
Rhode Island	117	91	73	42	—	—	323
Rice	183	132	104	35	52	4	510
Rochester	69	70	44	38	—	—	221
Rose	107	85	56	52	—	—	300
Rutgers	159	80	56	40	—	2	337
Santa Clara	69	44	23	9	4	—	149
So. Car. Uni.	102	68	120	22	—	—	312
S. Dak. St. Coll.	135	50	40	24	—	—	249
S. Dak. Mines	187	105	64	68	—	—	424
S. Meth.	115	46	39	29	25	—	254
Stanford	150	154	108	119	—	41	572
Stevens	265	178	135	134	—	—	712
Swarthmore	40	31	18	22	—	—	111
Syracuse	270	153	90	66	—	3	582
Tennessee	343	244	139	94	—	29	849
Tenn. Poly.	95	37	20	4	—	—	156
Texas A. & I.	50	35	18	18	—	3	124
*Texas A. & M.	1,974	644	420	277	5	22	3,342
Texas Mines	95	48	14	21	—	—	178
Texas Tech.	401	173	103	137	—	—	814
Texas Univ.	—	—	—	—	—	—	—

Enrollment of Undergraduate Engineering Students, 1942–43—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Thayer	110	50	30	25	—	20	235
Toledo	—	—	—	—	—	—	—
Tufts	151	112	88	70	—	—	421
Tulane	202	126	57	67	—	—	452
Tulsa	111	38	33	26	—	—	208
Union	—	—	—	—	—	—	—
Utah Agri.	91	63	31	37	2	1	225
Utah Uni.*	221	165	132	83	—	—	601
Vanderbilt	—	—	—	—	—	—	—
Vermont	55	26	30	29	—	—	140
Villanova	165	79	71	61	—	—	376
Va. Mil.	160	133	109	88	—	—	490
Va. Poly.	—	—	—	—	—	—	—
Virginia	111	55	41	51	—	—	258
Wash. (St. Louis)	213	166	83	64	—	—	526
Wash. Uni.	728	189	161	169	—	17	1,264
Wash. St. Coll.	309	141	100	111	—	4	665
Wayne	193	86	55	41	—	—	375
Webb Inst.	18	20	16	14	—	—	68
West Vir.	176	195	109	57	—	1	538
Wisconsin	—	—	—	—	—	—	—
Worcester	210	136	137	121	—	27	631
Wyoming	178	78	45	43	—	—	344

Enrollment of Undergraduate Engineering Students, 1942–43—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Totals
Yale	230	151	106	77	—	21	585
Total U. S.	36,389	22,070	16,372	13,214	884	722	89,651
Canadian Schools							
Ecole Poly	125	77	49	44	35	—	330
McGill	203	115	122	100	4	—	544
Nova Scotia	—	—	39	31	—	—	70
Queen's	232	164	117	118	—	—	631
Saskatchewan	335	123	84	70	—	—	612
Total	895	479	411	363	39	—	2,187
U. S. Schools	36,389	22,070	16,372	13,214	884	722	89,651
Grand total	37,284	22,549	16,783	13,577	923	722	91,838

ENGINEERING COLLEGE RESEARCH ASSOCIATION

On October 26, 1942, representatives of seventy-three engineering colleges from all parts of the nation met at Thorne Hall, Northwestern University, and under the chairmanship of Dean C. E. MacQuigg of Ohio State University organized the Engineering College Research Association. The immediate and urgent objective was to coöperate with the war production agencies of the Government in the prosecution and promotion of research needed for the management of the war. More specifically the purposes of the Association as expressed in the adopted constitution are:

a. To coöperate with the War Agencies of the Government in the prosecution and promotion of research needed for the war effort, and to assist in organizing the research facilities of engineering colleges to this end.
b. To assist in organizing the research facilities of the engineering colleges in the undertaking of research designed to promote post-war reconstruction and economic adjustment through new and improved processes affecting industry, public works, the conservation and development of natural resources, the public health, and similar activities.
c. To serve as a continuing agency for developing and coördinating industrial and scientific research and for furthering advanced study in the colleges of engineering of the United States.
d. To collaborate with other associations and with government agencies concerned with research in the interest of the maximum utilization and development of the engineering and scientific research facilities of the nation, to achieve coördination and prevent duplication of effort.

Coördinately with the defined objectives of its constitution, the Association seeks to encourage engineering colleges to set up research divisions with the highest criteria of effectiveness, of material assistance and of distinctive creativeness. Membership restrictions of the Engineering College Research Association were defined as follows:

a. Active Membership shall be confined to institutions of higher education granting degrees in engineering which normally require four or more academic years of study and which have one or more engineering curricula accredited by Engineers' Council for Professional Development, *provided* that its research organization or activity shall have existed for at least three (3) years and shall have expended for engineering research during the three fiscal years next preceding the date of its admission to the Association not less than ten thousand

dollars ($10,000). The term "research" as used herein means original investigations including the discovery of new processes, devices, or materials and does not include routine testing. Membership may preferably be taken out by the institution in the name of its Engineering Experiment Station, Engineering Research Institute or Divisions, or Engineering College or Department.

b. A member institution must maintain a high record of performance in engineering research to remain in good standing as an Active Member.

c. Associate Membership shall be confined to libraries, associations. companies, or individuals having an interest in engineering research such as to warrant in the opinion of the Council of the Association, affiliation with the Association. Associate Members shall have no vote, but may otherwise participate in all of the activities of the Association.

Under the constitution, the Association is authorized to accept gifts provided that such gifts are for the furtherance of the purposes of the Association. It was pointed out that through the coöperation of such a large number of leading engineering schools expensive and wasteful duplication of effort will be avoided and a maximum utilization of facilities and personnel and a high degree of coördination will result.

The officers elected at the organization meeting were Dean W. R. Woolrich of The University of Texas, President; Dean Earle B. Norris of Virginia Polytechnic Institute, First Vice-President; President C. C. Williams of Lehigh University, Second Vice-President; Dean R. L. Spencer of the University of Delaware, Treasurer. Directors who will serve on the Council one year are Dean Ivan C. Crawford of the University of Michigan and Dean Thorndike Saville of New York University. Those who will serve two years are Dean Samuel B. Morris of Stanford University and Dean F. M. Dawson of The University of Iowa. Directors elected for three years are Dean N. A. Christensen of Colorado State College and Dean G. M. Butler of the University of Arizona. The method of election and terms of officers are given in the constitution as follows:

"The President and Treasurer shall each serve for a term of two years. Each Vice-President shall serve for a term of two years except that at the first election a Vice-President shall be chosen for a term of one year and a Vice-President shall be chosen for a term of two years. Thereafter, one Vice-President shall be elected annually.

"Directors shall serve for terms of three years, except that at the organization meeting two directors shall be elected for one-year terms, two for two-year terms, and two for three-year terms. Thereafter, two Directors shall be elected annually, to serve for full terms of three years."

The initial meeting of the Council was held in Washington on November 27, 1942. Supplementary sessions were held on the same day with President Harvey N. Davis, Director of the Office of Production Research and Development, and with Senator Kilgore's Subcommittee on Manpower relative to the proposed Office of Technological Mobilization.

The Council is preparing a preliminary report on the engineering research now in progress for the Office of Production Research and Development and to serve as a basis for better coördination of kindred interests.

Frequent reports are to be forthcoming from the Council and a stepped-up program of engineering research encouraged throughout the nation. Further meetings are scheduled by the Council at Washington in January and at the Annual Meeting of the Society for the Promotion of Engineering Education in Chicago.

ORGANIZATION OF THE SOCIETY

The Society for the Promotion of Engineering Education was the outgrowth of the meetings of Division E of the World's Engineering Congress held in Chicago from July 21 to August 15, 1893, in connection with the World's Columbian Exposition.

The aim of the Society is the promotion of the highest ideals in the conduct of engineering education with respect to administration, curriculum, and teaching work, and the maintenance of a high professional standard among its members.

The means to this end include educational research, the holding of meetings for the reading and the discussion of professional papers, and the publication of papers, discussions, and communications as may seem expedient.

Each Society member should scrutinize carefully the membership list for his institution, as published in this year book, and interest his colleagues, who are not members, in Society membership.

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1943 Meeting, May 1, Univ. of Tennessee.

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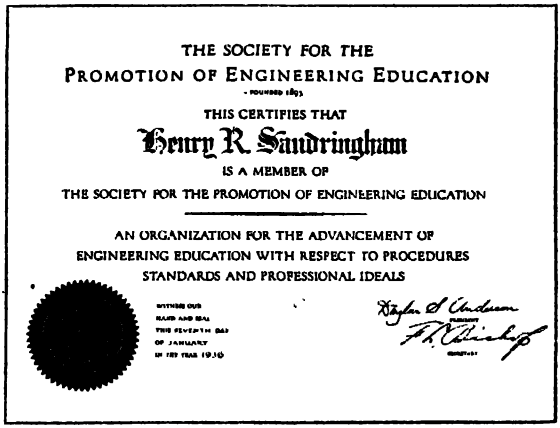
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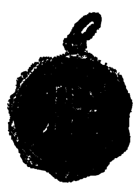

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UNIVERSITY OF CINCINNATI, Cincinnati, Ohio, Raymond Walters, President, R. C. Gowdy, Dean 1917
THE CITADEL, THE MILITARY COLLEGE OF SOUTH CAROLINA, Charleston, S. C., C. P. Summerall, President, L. S. LeTellier, Dean 1914
CLARKSON COLLEGE OF TECHNOLOGY, Potsdam, N. Y., John A. Ross, Jr., President, F. C. Wilson, Dean 1938
CLEMSON AGRICULTURAL COLLEGE, Clemson, S. C., Robert F. Poole, President, S. B. Earle, Dean 1913
COLORADO SCHOOL OF MINES, Golden, Colo., Melville F. Coolbaugh, President, Jesse R. Morgan, Dean 1929
COLORADO STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS, Fort Collins, Colo., Roy M. Green, President, N. A. Christensen, Dean 1923

* Active institutional members are accredited engineering colleges and distinguished national engineering societies.

UNIVERSITY OF COLORADO, Boulder, Colo., Robert L. Stearns, President, H. S. Evans, Dean 1915

COLUMBIA UNIVERSITY, New York City, N. M. Butler, President, Joseph W. Barker, Dean 1923

UNIVERSITY OF CONNECTICUT, Storrs, Conn., A. N. Jorgensen, President, J. H. Lampe, Dean 1941

THE COOPER UNION, New York City, Edwin S. Burdell, Director, G. F. Bateman, Dean 1927

CORNELL UNIVERSITY, Ithaca, N. Y., Edmund Ezra Day, President, S. C. Hollister, Dean 1913

UNIVERSITY OF DELAWARE, Newark, Del., Walter Hullihen, President, R. L. Spencer, Dean 1916

UNIVERSITY OF DENVER, Denver, Colo., Caleb F. Gates, Chancellor, C. M. Knudson, Dean 1941

UNIVERSITY OF DETROIT, Detroit, Mich., Charles H. Cloud, President, C. J. Freund, Dean 1924

DREXEL INSTITUTE OF TECHNOLOGY, Philadelphia, Pa., George P. Rea, President, R. C. Disque, Dean 1914

DUKE UNIVERSITY, Durham, N. C., R. L. Thomas, President, W. H. Hall, Director 1932

ECOLE POLYTECHNIQUE, Montreal, Canada, Augustin Frigon, President, Armand Circé, Dean 1917

ENGINEERING INSTITUTE OF CANADA, THE, 2050 Mansfield Street, Montreal, Canada, L. Austin Wright, Secretary 1924

UNIVERSITY OF FLORIDA, Gainesville, Fla., John J. Tigert, President, Joseph Weil, Dean 1928

GEORGE WASHINGTON UNIVERSITY, Washington, D. C., Cloyd Heck Marvin, President, F. M. Feiker, Dean 1913

GEORGIA SCHOOL OF TECHNOLOGY, Atlanta, Ga., M. L. Brittain, President, D. P. Savant, Dean 1913

THE GRADUATE SCHOOL OF ENGINEERING, Harvard University, Cambridge, Mass., James Bryant Conant, President, Harald M. Westergaard, Dean 1919

UNIVERSITY OF IDAHO, Moscow, Idaho, H. C. Dale, President, J. E. Buchanan, Dean 1924

ILLINOIS INSTITUTE OF TECHNOLOGY, Chicago, Ill., H. T. Heald, President 1921

UNIVERSITY OF ILLINOIS, Urbana, Ill., A. C. Willard, President, M. L. Enger, Dean 1914

IOWA STATE COLLEGE, Ames, Iowa, Charles E. Friley, President, T. R. Agg, Dean 1913

STATE UNIVERSITY OF IOWA, Iowa City, Iowa, Virgil M. Hancher, President, F. M. Dawson, Dean 1914

JOHNS HOPKINS UNIVERSITY, Baltimore, Md., Isaiah Bowman, President, W. B. Kouwenhoven, Dean 1921

KANSAS STATE COLLEGE OF AGRICULTURE AND APPLIED SCIENCE, Manhattan, Kans., F. D. Farrell, President, R. A. Seaton, Dean 1917

THE UNIVERSITY OF KANSAS, Lawrence, Kans., Deane W. Malott, Chancellor, Jay J. Jakosky, Dean 1914

UNIVERSITY OF KENTUCKY, Lexington, Ky., H. L. Donovan, President, James H. Graham, Dean 1925

LAFAYETTE COLLEGE, Easton, Pa., William Mather Lewis, President 1915

LEHIGH UNIVERSITY, Bethlehem, Pa., C. C. Williams, President, A. C. Callen, Dean 1914

LOUISIANA STATE UNIVERSITY, University, La., C. B. Hodges, Acting President, L. J. Lassalle, Dean 1934

UNIVERSITY OF LOUISVILLE, Louisville, Ky., Raymond A. Kent, President, F. L. Wilkinson, Dean 1925
McGILL UNIVERSITY, Montreal, Canada, F. Cyril James, Principal, E. Brown, Dean 1924
UNIVERSITY OF MAINE, Orono, Me., Arthur A. Hauck, President, Paul Cloke, Dean 1917
MANHATTAN COLLEGE, New York City, Rev. Bro. A. Victor, President, Rev. Bro. A. Leo, Dean 1933
MARQUETTE UNIVERSITY, Milwaukee, Wis., R. C. McCarthy, President, F. A. Kartak, Dean 1919
UNIVERSITY OF MARYLAND, College Park, Md., H. C. Byrd, President, S. S. Steinberg, Dean 1923
MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Cambridge, Mass., K. T. Compton, President, E. L. Moreland, Dean 1918
MICHIGAN COLLEGE OF MINING AND TECHNOLOGY, Houghton, Mich., Grover C. Dillman, President, James Fisher, Dean 1914
MICHIGAN STATE COLLEGE, East Lansing, Mich., R. S. Shaw, President, H. B. Dirks, Dean 1933
UNIVERSITY OF MICHIGAN, Ann Arbor, Mich., Alex G. Ruthven, President, Ivan C. Crawford, Dean 1913
UNIVERSITY OF MINNESOTA, Minneapolis, Minn., Walter C. Coffey, President, Samuel C. Lind, Dean 1919
MISSISSIPPI STATE COLLEGE, State College, Miss., G. D. Humphrey, President, L. L. Patterson, Dean 1939
UNIVERSITY OF MISSOURI, Columbia, Mo., F. A. Middlebush, President, H. A. Curtis, Dean 1914
MISSOURI SCHOOL OF MINES AND METALLURGY, Rolla, Mo., Curtis L. Wilson, Dean 1925
MONTANA SCHOOL OF MINES, Butte, Mont., F. A. Thomson, President 1938
MONTANA STATE COLLEGE, Bozeman, Mont., W. M. Cobleigh, Acting President 1923
UNIVERSITY OF NEBRASKA, Lincoln, Nebr., C. A. Boucher, Chancellor, O. J. Ferguson, Dean 1914
NEWARK COLLEGE OF ENGINEERING, Newark, N. J., Allan R. Cullimore, President, James A. Bradley, Dean 1922
UNIVERSITY OF NEW BRUNSWICK, Fredericton, N. B., Cecil C. Jones, President, John Stephens, Dean 1923
UNIVERSITY OF NEW HAMPSHIRE, Durham, N. H., Fred Englehardt, President, G. W. Case, Dean 1923
NEW MEXICO COLLEGE OF A. & M. ARTS, State College, N. M., H. M. Milton, President, D. B. Jett, Dean 1917
NEW MEXICO SCHOOL OF MINES, Socorro, N. M., R. H. Reece, President 1941
UNIVERSITY OF NEW MEXICO, Albuquerque, N. M., J. F. Zimmerman, President, M. E. Farris, Dean 1937
NEW YORK COLLEGE OF CERAMICS AT ALFRED UNIVERSITY, Alfred, N. Y., J. Nelson Norwood, President, Major E. Holmes, Dean 1938
THE COLLEGE OF THE CITY OF NEW YORK, New York, N. Y., H. N. Wright, President, A. B. Newman, Dean 1940
NEW YORK UNIVERSITY, New York, N. Y., Harry W. Chase, Chancellor, Thorndike Saville, Dean 1913
NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING, Division of the University of North Carolina, Raleigh, N. C., Frank P. Graham, President, B. R. Van Leer, Dean 1920
NORTH DAKOTA AGRICULTURAL COLLEGE, Fargo, N. D., F. L. Eversull, President, Harry S. Rush, Acting Dean 1924

UNIVERSITY OF NORTH DAKOTA, Grand Forks, N. D., John C. West, President, L. C. Harrington, Dean 1913

UNIVERSITY OF NOTRE DAME, Notre Dame, Ind., Hugh O'Donnell, President, D. C. Jackson, Jr., Dean 1914

NORTHEASTERN UNIVERSITY, Boston, Mass., Carl S. Ell, President, W. C. White, Dean 1921

NORTHWESTERN UNIVERSITY, Evanston, Ill., Franklyn B. Snyder, President, O. W. Eshbach, Dean 1939

NORWICH UNIVERSITY, Northfield, Vt., John M. Thomas, President, A. E. Winslow, Dean 1938

OHIO STATE UNIVERSITY, THE, Columbus, O., H. L. Bevis, President, Charles E. MacQuigg, Dean 1921

STATE UNIVERSITY OF OKLAHOMA, Norman, Okla., Joseph A. Brandt, President, W. H. Carson, Dean 1913

OKLAHOMA A. & M. COLLEGE, Stillwater, Okla., Henry G. Bennett, President, Philip S. Donnell, Dean 1933

OREGON STATE COLLEGE, Corvallis, Ore., A. L. Strand, President, R. H. Dearborn, Dean. 1917

THE PENNSYLVANIA STATE COLLEGE, State College, Pa., R. D. Hetzel, President, H. P. Hammond, Dean 1914

UNIVERSITY OF PENNSYLVANIA, Philadelphia, Pa.; Thos. S. Gates, President: Moore School of Electrical Engineering, Harold Pender, Dean 1930
Towne Scientific School, John A. Goff, Dean 1914

UNIVERSITY OF PITTSBURGH, Pittsburgh, Pa., John G. Bowman, Chancellor, E. A. Holbrook, Dean 1913

PRATT INSTITUTE, Brooklyn, N. Y., Charles Pratt, Secretary, A. L. Cook, Director 1939

PRINCETON UNIVERSITY, Princeton, N. J., Harold Willis Dodds, President, K. H. Condit, Dean 1922

PURDUE UNIVERSITY, Lafayette, Ind., Edward Charles Elliott, President, A. A. Potter, Dean 1915

QUEEN'S UNIVERSITY, Kingston, Ont., Canada, R. C. Wallace, Principal and Vice Chancellor, A. L. Clark, Dean 1922

RENSSELAER POLYTECHNIC INSTITUTE, Troy, N. Y., W. O. Hotchkiss, Director, R. P. Baker, Assistant Director 1922

RHODE ISLAND STATE COLLEGE, Kingston, R. I., Carl R. Woodward, President, Royal L. Wales, Dean 1913

RICE INSTITUTE, Houston, Tex., Edgar Odell Lovett, President, Harry B. Weiser, Dean 1924

UNIVERSITY OF ROCHESTER, Rochester, N. Y., Allan Valentine, President 1937

ROSE POLYTECHNIC INSTITUTE, Terre Haute, Ind., D. B. Prentice, President, Carl Wischmeyer, Vice President 1916

RUTGERS UNIVERSITY, New Brunswick, N. J., Robt. C. Clothier, President, P. H. Daggett, Dean 1914

UNIVERSITY OF SANTA CLARA, Santa Clara, Calif., Charles J. Walsh, President, G. L. Sullivan, Dean 1937

SOUTH DAKOTA STATE COLLEGE OF A. & M. ARTS, Brookings, S. D., Lyman E. Jackson, President, H. M. Crothers, Dean 1924

SOUTH DAKOTA STATE SCHOOL OF MINES, Rapid City, S. D., Jos. P. Connolly, President 1926

UNIVERSITY OF SOUTHERN CALIFORNIA, Los Angeles, Calif., R. B. von Kleinsmid, President, R. E. Vivian, Acting Dean 1938

SOUTHERN METHODIST UNIVERSITY, Dallas, Texas, Umphrey Lee, President, E. H. Flath, Dean 1929

STANFORD UNIVERSITY, Stanford University, Calif., Donald B. Tresidder, President, Samuel B. Morris, Dean 1917
STEVENS INSTITUTE OF TECHNOLOGY, Hoboken, N. J., Harvey N. Davis, President, Franklin DeR. Furman, Dean 1913
SWARTHMORE COLLEGE, Swarthmore, Pa., John W. Nason, President, Scott B. Lilly, Chairman 1921
SYRACUSE UNIVERSITY, Syracuse, N. Y., William P. Tolley, Chancellor, Louis Mitchell, Dean 1913
UNIVERSITY OF TENNESSEE, Knoxville, Tenn., James D. Hoskins, President, N. W. Dougherty, Dean 1921
A. & M. COLLEGE OF TEXAS, College Station, Tex., Thomas O. Walton, President, Gibb Gilchrist, Dean 1916
TEXAS TECHNOLOGICAL COLLEGE, Lubbock, Tex., Clifford B. Jones, President, O. V. Adams, Dean 1931
UNIVERSITY OF TEXAS, Austin, Tex., Homer P. Rainey, President, W. R. Woolrich, Dean 1919
THAYER SCHOOL OF ENGINEERING AT DARTMOUTH COLLEGE, Hanover, N. H., Ernest M. Hopkins, President, Frank W. Garran, Dean 1940
UNIVERSITY OF TOLEDO, Toledo, Ohio, P. C. Nash, President, D. M. Palmer, Dean 1915
UNIVERSITY OF TORONTO, Toronto, Ont., Canada, H. J. Cody, President, C. R. Young, Dean 1917
TUFTS COLLEGE, Medford, Mass., Leonard Carmichael, President, H. P. Burden, Dean 1914
TULANE UNIVERSITY OF LOUISIANA, New Orleans, La., R. C. Harris, President, J. M. Robert, Dean 1921
UNIVERSITY OF TULSA, Tulsa, Okla., C. I. Pontius, President, R. L. Langenheim, Dean 1940
UNION COLLEGE, Schenectady, N. Y., Dixon Ryyan Fox, President, H. W. Bibber, Administrative Head, Division of Engineering 1937
UNITED STATES COAST GUARD ACADEMY, New London, Conn., Capt. James Pine, Supt. 1939
UTAH STATE AGRICULTURAL COLLEGE, Logan, Utah, Elmer G. Peterson, President, G. D. Clyde, Dean 1940
UNIVERSITY OF UTAH, Salt Lake City, Utah, LeRoy E. Cowles, President, A. Leroy Taylor, Dean 1914
VANDERBILT UNIVERSITY, Nashville, Tenn., Oliver C. Carmichael, Chancellor, F. J. Lewis, Dean 1914
UNIVERSITY OF VERMONT, Burlington, Vt., G. F. Eckhard, Dean 1915
VILLANOVA COLLEGE, Villanova, Pa., E. V. Stanford, President, J. S. Morehouse, Dean 1921
VIRGINIA MILITARY INSTITUTE, Lexington, Va., C. E. Kilbourne, Superintendent, S. W. Anderson, Academic Executive 1937
VIRGINIA POLYTECHNIC INSTITUTE, Blacksburg, Va., Julian A. Burruss, President, E. B. Norris, Dean 1924
UNIVERSITY OF VIRGINIA, University, Va., J. L. Newcomb, President, W. S. Rodman, Dean 1915
WASHINGTON UNIVERSITY, St. Louis, Mo., George R. Throop, Chancellor, A. S. Langsdorf, Dean 1914
STATE COLLEGE OF WASHINGTON, Pullman, Wash., E. O. Holland, President, R. D. Sloan, Dean 1924
UNIVERSITY OF WASHINGTON, Seattle, Wash., Lee Paul Sieg, President, Edgar A. Loew, Dean 1934

WEBB INSTITUTE OF NAVAL ARCHITECTURE, New York City, George H. Rock, Dean 1937
WEST VIRGINIA UNIVERSITY, Morgantown, W. Va., C. E. Lawall, President, R. P. Davis, Dean 1937
UNIVERSITY OF WISCONSIN, Madison, Wis., Clarence A. Dykstra, President, F. Ellis Johnson, Dean 1914
WORCESTER POLYTECHNIC INSTITUTE, Worcester, Mass., Wat T. Cluverius, President, F. W. Roys, Dean 1913
UNIVERSITY OF WYOMING, Laramie, Wyo., A. G. Crane, President, R. D. Goodrich, Dean 1925
YALE UNIVERSITY, New Haven, Conn., Charles Seymour, President, S. W. Dudley, Dean 1917

ASSOCIATE *

ARKANSAS POLYTECHNIC COLLEGE, Russellville, Ark., C. R. Nichols, Dean 1940
BLISS ELECTRICAL SCHOOL, Takoma Park, Washington, D. C., Louis D. Bliss, President, Milton M. Flanders, Dean 1939
FENN COLLEGE, Cleveland, Ohio, C. V. Thomas, President, B. H. Bush, Dean 1940
FRANKLIN TECHNICAL INSTITUTE, Boston, Mass., B. K. Thorogood, Director 1940
UNIVERSITY OF HAWAII, Honolulu, T. H., David L. Crawford, President, A. R. Keller, Dean 1923
HOWARD UNIVERSITY, Washington, D. C., M. W. Johnson, President, L. K. Downing, Dean 1937
KANSAS STATE TEACHERS COLLEGE, Pittsburg, Kansas, Rees H. Hughes, President, J. A. G. Shirk, Dean 1937
LOS ANGELES JUNIOR COLLEGE, Los Angeles, Calif. R. C. Ingalls, Director, George W. Duncan, Chairman, Engineering Department 1937
OHIO MECHANICS INSTITUTE, Cincinnati, Ohio, John T. Faig, President .. 1940
OHIO NORTHERN UNIVERSITY, Ada, Ohio, Robert Williams, President, J. A. Needy, Dean 1937
UNIVERSITY OF PORTO RICO, Rio Piedras, P. R., R. G. Tugwell, Chancellor, R. M. Ramos, Dean 1920
SCRANTON-KEYSTONE JUNIOR COLLEGE, La. Plume, Pa., B. S. Hollingshead, President, J. A. Strelzoff, Chairman 1937
TEXAS COLLEGE OF ARTS & INDUSTRIES, Kingsville, Texas, J. O. Loftin, President, R. L. Peurifoy, Director 1937
WESTINGHOUSE TECHNICAL NIGHT SCHOOL, East Pittsburgh, Pa., R. A. McPherson, Manager 1924

Total institutional members:

Active	140
Associate	14
	154

*** An associate member may become an active member when one or more of its curriculums are accredited by the E. C. P. D.**

INDIVIDUAL MEMBERS.

Revised to February 23, 1943

AAKHUS, THEODORE, Assistant Professor of Engineering Drawing, University of Nebraska, Lincoln, Nebr. 1933
ABBETT, ROBERT W., Assistant Professor of Civil Construction, Union College, Schenectady, N. Y. 1936
ABBITT, WILLIAM H., Associate Professor of Physics, Carleton College, Northfield, Minn. 1941
ABBOTT, RAYMOND B., Professor of Physics, Purdue University, Lafayette, Ind. 1928
ABBOTT, ROBINSON, Somerville, Mass. 1919
ABBUHL, FRED, Associate Professor of English, Rensselaer Polytechnic Institute, Troy, N. Y. 1939
ACKENHEIL, ALFRED C., Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. 1941
ACKERMAN, ADOLPH J., Director of Engineering, Dravo Corporation, Neville Island, Pittsburgh, Pa. 1941
ADAMS, ARTHUR S., Assistant Dean, College of Engineering, Cornell University, Ithaca, N. Y. **In military service** 1931
ADAMS, CHARLES J., Professor and Head, Dept. of English, Worcester Polytechnic Institute, Worcester, Mass. 1937
ADAMS, DOUGLAS P., Instructor in Graphics, Massachusetts Institute of Technology, Cambridge, Mass. 1941
ADAMS, FRANCIS J., Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1912
ADAMS, HENRY C., Assistant Professor of Naval Architecture and Marine Engineering, University of Michigan, Ann Arbor, Mich. 1940
ADAMS, OTTO V., Dean of Engineering, Texas Technological College, Lubbock, Texas 1930
ADAMS, RALPH G., In charge of Courses, Franklin Union Technical Institute, Boston, Mass. 1940
ADAMS, THOMAS C., 242 S. 12th St. E., Salt Lake City, Utah 1930
ADAMS, WILLIAM E., Assistant Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1939
ADES, CLIFFORD S., Assistant Professor and Head, Dept. of Engineering, Denison University, Granville, Ohio 1936
AGER, RAYMOND W., Associate Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. 1940
AGG, THOMAS R., Dean of Engineering, Director, Engineering Experiment Station, Iowa State College, Ames, Iowa 1923
AHLQUIST, ROBERT W., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Iowa 1929
AIKEN, C. C., Director, Training Course, R.C.A. Mfg. Co., Camden, N. J. 1939
AIKEN, HENRY B., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. 1937
AITKENHEAD, WM., Professor and Head, Dept. of Agricultural Engineering, Purdue University, Lafayette, Ind. 1924
AKERMAN, JOHN D., Professor and Head, Department of Aeronautical Engineering, University of Minnesota, Minneapolis, Minn. * 1931

ALBERT, ARTHUR L., Professor of Communication Engineering, Oregon State College, Corvallis, Ore. 1929
ALBERT, CALVIN D., Professor and Head, Dept. of Machine Design, Cornell University, Ithaca, N. Y. 1938
ALBERT, ODD, Assistant Professor of Structural Engineering, Director of Publicity, Newark College of Engineering, Newark, N. J. 1938
ALBRIGHT, PENROSE S., Chairman, Division of Natural Sciences, Southwestern College, Winfield, Kans. 1932
ALDRICH, BENJAMIN M., Assistant Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1932
ALDRICH, MILTON H., Assistant Professor of Civil Engineering, University of Vermont, Burlington, Vt. 1939
ALEXANDER, NICHOLAS, Professor of Aeronautical Engineering, Rhode Island State College, Kingston, R. I. 1937
ALEXANDER, WILLIAM T. 1929
ALGER, PHILIP L., Chairman, General Standardizing Committee, General Electric Company, Schenectady, N. Y. 1925
ALGREN, AXEL B., Assistant Professor of Mechanical Engineering, Assistant Director, Engineering Experiment Station, University of Minnesota, Minneapolis, Minn. 1929
ALLAN, WILLIAM, Associate Professor of Civil Engineering, Chairman of Dept., College of the City of New York, New York City 1935
ALLEN, C. FRANK, Retired, 88 Montview St., West Roxbury, Mass. (*President, 1903–4; Secretary, 1895–7; Vice President, 1898–9; Member of Council since 1895.*) 1893
ALLEN, CHESTER L., Professor and Head, Dept. of Civil Engineering, Michigan State College, East Lansing, Mich. 1917
ALLEN, C. M., Professor of Hydraulic Engineering, Director, Alden Hydraulic Lab., Worcester Polytechnic Institute, Worcester, Mass. 1903
ALLEN, ELBERT F., Professor of Mathematics, A. & M. College of Oklahoma, Stillwater, Okla. 1937
ALLEN, GEORGE M., Assistant Professor of Drafting, Executive Officer, Columbia University, New York, N. Y. 1941
ALLEN, ROBERT L., Instructor in Mechanical Engineering, Georgia School of Technology, Atlanta, Ga. 1937
ALLEN, RUSSELL B., Associate Professor of Civil Engineering, University of Maryland, College Park, Md. 1937
ALLIASON, ALBERT R., Head and Associate Professor of Electrical Engineering, Wayne University, Detroit, Mich. 1938
ALLISON, WILLIAM H., Associate Professor of Civil Engineering, Clarkson College of Technology, Potsdam, N. Y. 1928
ALLURED, ROBERT B., Associate Professor of Electrical Engineering, Arkansas Polytechnic College, Russellville, Ark. **In military service** 1940
ALMY, LOREN B., Assistant Professor of Civil Engineering, University of North Dakota, Grand Forks, N. D. 1941
AMBERG, CHARLES R., Professor of Ceramic Engineering, New York State College of Ceramics, Alfred, N. Y. 1941
AMBROSIUS, EDGAR E., Associate Professor and Head, Dept. of Mechanical Engineering, University of Kansas, Lawrence, Kansas 1941
AMELOTTI, EMIL, Assistant Professor of Mathematics, Villanova College, Villanova, Pa. 1938
AMIDON, LEE L., Professor and Head, Dept. of Mechanical Engineering, South Dakota State College, Brookings, S. D. 1928
ANDERSEN, PAUL, Associate Professor of Structural Engineering, University of Minnesota, Minneapolis, Minn. 1934

ANDERSON, C. A., Associate Professor of Engineering, University of Pittsburgh, Johnstown Center, Johnstown, Pa. 1926
ANDERSON, CARL G., Assistant Professor of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1940
ANDERSON, C. EDWARD, Professor and Chairman, Dept. of Mechanical Engineering, University of Wyoming, Laramie, Wyo. 1928
ANDERSON, D. S., Dean Emeritus, Tulane University; Ogunquit, Maine. (*Member of Council, 1926–9, 1935–; Vice President, 1931–32; President, 1935–36.*) 1900
ANDERSON, HAROLD W., Professor of Electrical Engineering, Iowa State College, Ames, Iowa 1925
ANDERSON, JAMES A., Dean of the Faculty, Head, Dept. of Civil Engineering, Virginia Military Institute, Lexington, Va. 1922
ANDERSON, JOHN, Professor of Civil Engineering, The Citadel, Charleston, S. C. 1936
ANDERSON, NEWTON H., Supervisor of Training Education Dept., Douglas Aircraft Co., Inc., Santa Monica, Calif. 1942
ANDERSON, VICTORIA, Associate in English, University of Washington, Seattle, Wash. 1939
ANDES, AMMON S., Assistant Professor of Mechanical Engineering, Washington State College, Pullman, Wash. 1937
ANDRAE, STEPHAN C., 865 N. Mentor Ave., Pasadena, Calif. 1939
ANDRES, PAUL G., Associate Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1941
ANDREWS, CARL B., Professor of Engineering, University of Hawaii, Honolulu, T. H. (405 Charles St., E. Lansing, Mich.) 1925
ANDREWS, GORDON O., Manager, Personnel Division, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del. 1942
ANDREWS, STEPHEN C., Associate Professor of Business Administration, Virginia Polytechnic Institute, Blacksburg, Va. 1934
ANGERMANN, WILLIAM G., Associate Professor of Electrical Engineering, University of Southern California, Los Angeles, Calif. 1937
ANTHONY, RICHARD L., Professor of Mechanical Engineering, Rutgers University, New Brunswick, N. J. 1937
APPLEBY, ALFRED N., Instructor in Drafting, College of the City of New York, New York City 1940
APPLEGATE, C. E., Field Engineer, Technical Division, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. 1941
ARDUSER, LEON P., Executive Assistant, E. S. M. D. T., University of Alabama, University, Ala. 1925
ARENSON, SAUL B., Professor of Inorganic-Chemistry, University of Cincinnati, Cincinnati, Ohio 1938
ARM, DAVID L., Professor and Head, Dept. of Mechanical Engineering, Iowa State College, Ames, Iowa 1934
ARMSBY, HENRY H., Field Coordinator, E. S. M. D. T., U. S. Office of Education, Washington, D. C. (*Member of Council, 1938–41*) 1917
ARMSTRONG, EDWIN H., Professor of Electrical Engineering, Columbia University, New York City 1937
ARMSTRONG, W. H., Instructor in Industrial Engineering, The Pennsylvania State College, State College, Pa. 1937
ARNETT, LAWRENCE C., Instructor in Electrical Engineering, Howard University, Washington, D. C. 1941
ARNOLD, JAMES E., Assistant Professor of Aeronautical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1938

ARNOLD, J. NORMAN, Assistant Professor of Engineering Drawing, Purdue University, Lafayette, Ind. 1933
ASHTON, MERTON E., Alumni Secretary, Norwich University, Northfield, Vt. 1940
ATKINSON, FREDERICK G., Lt. Col., Air Corps Hdq., Army Air Forces, Washington, D. C. 1937
ATKINSON, MARGARET B., Assistant Professor of Engineering Drawing, Texas Technological College, Lubbock, Texas 1937
ATTWOOD, STEPHEN S., Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1926
ATWOOD, L. L., Professor and Head, Dept. of Language and History, Worcester Polytechnic Institute, Worcester, Mass. 1939
AUBERT, BROTHER, Assistant Professor of Civil Engineering, Manhattan College, New York City 1935
AUBURN, NORMAN P., Dean, Evening College, University of Cincinnati, Cincinnati, Ohio 1942
AULICH, WITOLD M., Professor of Mechanology, Polytechnic of Lwow, ul. Dunin-Borkowskich 2, Lwow, Poland 1930
AULT, E. STANLEY, Professor of Machine Design, Purdue University, Lafayette, Ind. 1925
AUTENREITH, GEORGE C., Professor and Chairman, Dept. of Drafting, College of the City of New York, New York City 1927
AYER, FRED. E.,* Dean, College of Engineering and Commerce, University of Akron, Akron, O. (*Member of Council, 1933–36.*) 1907
AYERS, JOSEPH A., Associate Professor of English, University of Louisville, Louisville, Ky 1939
AYERS, MAURICE T., Assistant Professor of General Engineering, Rutgers University, New Brunswick, N. J. 1938
AYRE, ROBERT S., Associate Mechanical Engineer, Naval Ordnance Lab., Washington, D. C. 1939
AYRES, EDMUND D., Professor of Electrical Engineering, The Ohio State University, Columbus, Ohio 1934
AYRES, QUINCY C., Commander U. S. N. R., Bureau of Yards and Docks, Washington, D. C. 1926
BABBITT, HAROLD E., Professor of Sanitary Engineering, University of Illinois, Urbana, Ill. 1922
BABCOCK, JOHN B., Professor of Railway Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1923
BABCOCK, M. M., Associate Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. 1936
BACCUS, IRA B., Associate Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. 1942
BACKER, LESLIE H., Professor of Chemistry, Stevens Institute of Technology, Hoboken, N. J. 1930
BACKER, LOUIS B., Professor of Physics, Manhattan College, New York City 1936
BACON, RINALDO A., Instructor in Mechanical Engineering, University of Texas, Austin, Texas 1939
BAGLEY, JAMES W., Lecturer in Geography, Institute of Geographical Exploration, Harvard University, Cambridge, Mass. 1942
BAIER, LOUIS A., Associate Professor of Naval Architecture and Marine Engineering, University of Michigan, Ann Arbor, Mich. 1940
BAILEY, BENJ. F., Professor and Head, Dept. of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1920

BAILEY, CHARLIE R., Specialist, E. S. M. W. T., U. S. Office of Education, Washington, D. C. 1942
BAILEY, NEIL P., Research Engineer, Research Lab., General Electric Co., Schenectady, N. Y. 1930
BAILEY, WAYLAND S., Assistant Professor of Mechanical Engineering, Northeastern University, Boston, Mass. 1937
BAIN, WILLIAM A., Assistant Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. **In military service** 1939
BAINER, ROY, Associate Professor of Agricultural Engineering, University of California, Davis, Calif. 1933
BAKER, CHESTER P., Professor and Chairman, Dept. of Chemical Engineering, Northeastern University, Boston, Mass. 1926
BAKER, E. DOUGLAS, Associate Professor of Mathematics, Newark College of Engineering, Newark, N. J. 1926
BAKER, EDWARD G., Associate Professor of Mathematics, Newark College of Engineering, Newark, N. J. 1934
BAKER, EDWIN M., Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich. 1937
BAKER, ELLIS C., Professor in charge, Dept. of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1925
BAKER, JOHN B., Assistant Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937
BAKER, RALPH D., Associate Professor of Mechanical Engineering, University of Utah, Salt Lake City, Utah 1940
BAKER, RAY P., Assistant Director, Rensselaer Polytechnic Institute, Troy, N. Y. 1919
BAKER, SAMUEL, Dean, Schools of Technology, International Correspondence Schools, Scranton, Pa. 1935
BAKHMETEFF, BORIS A., Professor of Civil Engineering, Columbia University, New York City 1937
BALINT, ANTHONY T., Assistant Professor of Technical Drawing, Illinois Institute of Technology, Chicago, Ill. 1942
BALL, ALBERT, Professor Emeritus, Cooper Union, New York, N. Y. 1908
BALL, THEODORE R., Associate Professor of Chemistry, Washington University, St. Louis, Mo. 1930
BALLARD, LYMAN J., Professor of Engineering and Physics, Webb Institute of Naval Architecture, New York City 1939
BALSBAUGH, JAYSON C., Associate Professor of Electric Production and Distribution, Massachusetts Institute of Technology, Cambridge, Mass. 1938
BANGS, JOHN R., JR., Professor and Head, Dept. of Administrative Engineering, Cornell University, Ithaca, N. Y. 1932
BANKS, CHARLES W., Head, Department of Applied Science, Wentworth Institute, Boston, Mass. 1937
BANMILLER, PAETRUS F., Registrar, Villanova College, Villanova, Pa. 1941
BANTEL, E. C. H., Professor of Civil Engineering, Assistant Dean, University of Texas, Austin, Texas 1925
BARBER, WILLIAM J., Assistant Professor of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1937
BARCLAY, LELAND, Assistant Professor of Civil Engineering, University of Texas, Austin, Texas 1938
BARDSLEY, CLARENCE E., Engineer, Flood Control, U. S. Corps Army Engineers, Pittsburgh, Pa. 1937
BARKER, CHARLES L., Assistant Professor of Hydraulic Engineering, Washington State College, Pullman, Wash. 1928

BARKER, GEORGE J., Associate Professor of Mining and Metallurgy, University of Wisconsin, Madison, Wis. 1935
BARKER, JOSEPH W., Dean, Faculty of Engineering, Columbia University, New York, N. Y. (*Member of Council, 1935–8.*) 1926
BARLOW, HOWARD W., Professor and Head, Dept. of Aeronautical Engineering, A. & M. College of Texas, College Station, Texas 1940
BARLOW, ROLAND W., Director of Public Relations, Industrial Training Institute, 2154 Lawrence Ave., Chicago, Ill. 1939
BARNARD, NILES H., Associate Professor of Mechanical Engineering, University of Nebraska, Lincoln, Nebr. 1930
BARNARD, W. N., Director, Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y. (*Member of Council, 1923–6.*) 1910
BARNES, F. A., Professor of Railroad Engineering, Cornell University, Ithaca, N. Y. 1904
BARNES, GEORGE E., Professor of Hydraulic and Sanitary Engineering, Head, Dept. of Civil Engineering, Case School of Applied Science, Cleveland, Ohio 1933
BARNES, JOHN L., Chairman, Dept. of Mathematics, Tufts College, Medford, Mass. (On leave, with Bell Tel. Labs., N. Y. C.) 1938
BARNES, JOHN S., College Representative, John Wiley & Sons, Inc., 440 Fourth Ave., New York City 1940
BARNES, RALPH M., Professor of Industrial Engineering, Director of Personnel, State University of Iowa, Iowa City, Iowa 1929
BARNES, WILSON R., Instructor in Chemical Engineering, University of Louisville, Louisville, Ky. 1939
BARNWELL, GEORGE W., Professor of Production Practice, Stevens Institute of Technology, Hoboken, N. J. 1932
BARRETT, EDWARD C., Technologist, The National Bureau of Standards, Washington, D. C. 1938
BARRETT, SAMPSON K., Assistant Dean in charge of Evening Division; Professor of Electrical Engineering, New York University, New York City 1928
BARRIE, JOHN G., Assistant Professor of Mechanical Engineering, New York University, New York City 1938
BARROWS, H. K., Consulting Engineer, 6 Beacon St., Boston, Mass 1902
BARROWS, W. E., JR., Professor of Electrical Engineering, University of Maine, Orono, Me. 1908
BARRY, JOHN G., Instructor in Electrical Engineering, Princeton University, Princeton, N. J. 1941
BARTLAM, EDWARD R., Principal, Ceylon Technical Schools, Colombo, Ceylon 1937
BARTLETT, GRADY W., Assistant Professor of Physics, North Carolina State College, Raleigh, N. C. 1937
BARTLETT, HOWARD R., Head, Dept. of English and History, Massachusetts Institute of Technology, Cambridge, Mass. 1939
BARTLETT, R. S., Researcher in Engineering Education, Newark College of Engineering, Newark, N. J. **In military service** 1941
BARTON, MILLARD V., Professor of Aeronautical Engineering, University of Texas, Austin, Texas 1939
BARTOW, EDWARD, Professor and Head, Department of Chemistry and Chemical Engineering, State University of Iowa, Iowa City, Ia. 1921
BASORE, CLEBURNE A., Professor of Chemical Engineering, Assistant Director, Engineering Experiment Station, Alabama Polytechnic Institute, Auburn, Ala. 1938

BASS, FREDERIC, Chairman, Department of Civil Engineering, University of Minnesota, Minneapolis, Minn. (*Member of Council 1918–21.*) .. 1908

BASS, LAWRENCE W., Director, New England Industrial Research Foundation, Inc., 137 Newbury St., Boston, Mass. 1942

BATEMAN, GEORGE F., Dean, Schools of Engineering, Professor of Mechanical Engineering, The Cooper Union, New York City 1925

BATES, HERBERT T., Instructor in Chemical Engineering, Case School of Applied Science, Cleveland, Ohio 1941

BAUER, EDWARD E., Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1936

BAUER, F. S., Professor and Head, Dept. of Engineering Drawing and Machine Design, University of Colorado, Boulder, Colo. 1914

BAUER, GEORGE C., Chief Engineer, Curtiss Wright Technical Institute, Glendale, Calif. 1941

BAUER, JOHN V., Instructor in Civil Engineering, College of the City of New York, New York City 1940

BAUER, WM. M., Professor and Head, Dept. of Electrical Engineering, University of South Carolina, Columbia, S. C. 1933

BAUM, HARRY, Professor of Electrical Engineering, College of the City of New York, New York City 1927

BAUMGARTEN, WILLIAM L., Assistant Professor of Architecture, North Carolina State College, Raleigh, N. C. 1940

BAUMIESTER, THEODORE, JR., Professor and Executive Officer, Dept. of Mechanical Engineering, Columbia University, New York City 1935

BAUWENS, GEORGE O., Assistant Professor of Civil Engineering, University of Southern California, Los Angeles, Calif. 1941

BAXTER, CHARLES H., Professor and Head, Dept. of Civil and Mining Engineering, Michigan College of M. & T., Houghton, Mich. 1935

BAXTER, ROBERT A., Associate Professor of Chemistry and Gas Engineering, Colorado School of Mines, Golden, Colo. 1925

BAYLESS, W. A., Technical Editor, United Aircraft Corp., Stratford, Conn. 1938

BEACH, GEORGE R., Assistant Manager of Service, Remington Arms Co., Bridgeport, Conn. 1939

BEACH, ROBIN, Professor and Head, Dept. of Electrical Engineering, The Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1917

BEAL, GEORGE M., Professor of Architecture, University of Kansas, Lawrence, Kansas. **In military service** 1935

BEAL, ROBERT W., Instructor in Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa. **In military service** 1937

BEAM, ROBERT E., Assistant Professor of Electrical Engineering, Northwestern University, Evanston, Ill. 1942

BEATTY, FRED B., Associate Professor of Electrical Engineering, Colorado State College, Fort Collins, Colo. 1936

BEATTY, H. RUSSELL, Head, Dept. of Industrial Management, Pratt Institute, Brooklyn, N. Y. 1937

BEAVER, J. L., Professor and Acting Head, Dept. of Electrical Engineering, Lehigh University, Bethlehem, Pa. 1914

BEBIE, JULES, Professor of Chemical Technology, Washington University, St. Louis, Mo. 1936

BECHTOLD, CARL W., Instructor in Mechanics, University of Alabama, Tuscaloosa, Ala. 1941

BECK, LESTER E., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1931

BECKER, SYLVANUS A., Associate Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. 1933
BECKER, W. M., 332 3d St., Barberton, Ohio 1939
BEESE, CHARLES W., Professor of Industrial Engineering, Head, Dept. of General Engineering, Purdue University, Lafayette, Ind. 1938
BEGEMAN, MYRON L., Professor of Mechanical Engineering, Supt. Engineering Shops, University of Texas, Austin, Texas. **In military service** 1937
BEGG, ROBERT B. H., Professor of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1927
BEHRENS, ROBERT G., Manager, College Dept., Associated Technical Publications, 1555 W. 79th Street, Chicago, Ill. 1935
BEISLER, WALTER H., Professor and Head, Dept. of Chemical Engineering, University of Florida, Gainesville, Fla. 1936
BEITLER, SAMUEL R., Associate Professor of Hydraulic Engineering, The Ohio State University, Columbus, Ohio 1926
BELKNAP, J. HARRISON, Manager, Technical Employment and Training, Westinghouse E. & M. Co., Pittsburgh, Pa. (*Member of Council, 1941–4.*) **In military service** 1938
BELZ, CHARLES J., Professor and Head, Dept. of Civil Engineering, University of Dayton, Dayton, Ohio 1929
BENEDICT, OTIS, JR., Instructor in Machine Shop Practice, Pratt Institute, Brooklyn, N. Y. 1929
BENEDICT, R. RALPH, Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1939
BENFORD, WM. R., Assistant Professor of Civil Engineering, Brown University, Providence, R. I. **In military service** 1932
BENGTSON, NELS A., Dean, University Junior Division, Professor of Geography, University of Nebraska, Lincoln, Nebr. 1940
BENJAMIN, CURTIS G., Vice President, McGraw-Hill Book Co., Inc., 330 W. 42d St., New York City 1933
BENKERT, HARRY N., Assistant Professor of Civil Engineering, The Pennsylvania State College, State College, Pa. 1938
BENNER, J. ALFRED, Associate Professor of Mathematics, Lafayette College, Easton, Pa. 1931
BENNETT, ALBERT A., Professor of Mathematics, Brown University, Providence, R. I. **In military service** 1936
BENNETT, CLARENCE E., Professor and Head, Dept. of Physics, University of Maine, Orono, Me. 1937
BENNETT, EARL F., Assistant Professor of Civil Engineering, University of Maine, Orono, Me. 1939
BENNETT, EDW., Professor and Chairman, Dept. of Electrical Engineering, University of Wisconsin, Madison, Wis. (*Member of Council, 1923–6; Vice President, 1929–30.*) 1909
BENNETT, HARRY F., District Engineer, Dept. of Public Works, Box 668, London, Ont., Canada 1940
BENNETT, J. GARDNER, Professor of Civil Engineering, Robert College, Istanbul, Turkey 1932
BENNETT, RALPH D., Professor of Electrical Measurements, Massachusetts Institute of Technology, Cambridge, Mass. **In military service** .. 1937
BENNETT, W. H., Director of Research, Electronic Research Corp., 68 Craftsland Road, Brookline, Mass. 1939
BENSON, ARNOLD, Chairman, Dept. of Electrical Engineering, University of Denver, Denver, Colo. 1941

BENSON, FRED J., Acting Associate Professor of Civil Engineering, A. & M. College of Texas, College Station, Texas 1938
BENSON, LEONARD R., Instructor in Mechanical Engineering, University of Texas, Austin, Texas 1939
BERARD, SAMUEL J., Associate Professor of Engineering Drawing, Brown University, Providence, R. I. 1912
BERESFORD, HOBART, Professor and Head, Department of Agricultural Engineering, University of Idaho, Moscow, Idaho 1929
BERGER, FRANZ A., Professor of Mechanical Engineering, Washington University, St. Louis, Mo. 1924
BERGGREN, WILLARD P., Assistant Professor of Physics, University of California, Davis, Calif. 1934
BERKEL, HOWARD J., Instructor in Civil Engineering, Iowa State College, Ames, Iowa. **In military service** 1938
BERNHARD, RUDOLF K., 216 Pearl St., New York City 1940
BERNIER, JEAN C., Assistant Professor of Physics and Communications, Ecole Polytechnique, Montreal, Canada 1942
BERRY, C. HAROLD, Gordon McKay Professor of Mechanical Engineering, Harvard University, Cambridge, Mass. 1928
BERRY, EDWARD F., Professor and Head, Dept. of Civil Engineering, Syracuse University, Syracuse, N. Y. 1928
BERRY, GEORGE M., Lecturer in Metallurgy, Instructor in Foundry Practice, Syracuse University, Syracuse, N. Y. 1941
BERRY, H. C., Professor of Materials of Construction, University of Pennsylvania, Philadelphia, Pa. (*Member of Council, 1923–6.*) 1916
BERRY, W. J., Professor and Head, Department of Mathematics, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1910
BERRYMAN, LLOYD G., Acting Associate Professor of Mechanical Engineering, A. & M. College of Texas, College Station, Texas 1939
BESSEY, WM. H., Instructor in Physics, Carnegie Institute of Technology, Pittsburgh, Pa. 1940
BEST, HERBERT W., Assistant Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1935
BETHEL, LAWRENCE L., Director, New Haven Y. M. C. A. Junior College, 15 Prospect St., New Haven, Conn. 1942
BETTENCOURT, WILLIAM, Director of Mechanical Drawing, Belmont Senior High School, Belmont, Mass. 1941
BEWLEY, L. V., Professor and Head, Dept. of Electrical Engineering, Lehigh University, Bethlehem, Pa. **In military service** 1940
BIBB, SAMUEL F., Associate Professor of Mathematics, Illinois Institute of Technology, Chicago, Ill. 1935
BIBBER, HAROLD W., Professor of Electrical Engineering, Chairman, Engineering Division, Union College, Schenectady, N. Y. 1922
BIDWELL, CHARLES C., Professor and Head, Dept. of Physics, Lehigh University, Bethlehem, Pa. 1927
BIEGLER, PHILIP S., Professor and Head, Dept. of Electrical Engineering, University of Southern California, Los Angeles, Calif. 1925
BIGELOW, JAMES H., Personnel Supervisor, New York Telephone Co., 140 West Street, New York City 1938
BILLINGS, ERLE M., Business and Technical Personnel Director, Eastman Kodak Co., 343 State St., Rochester, N. Y. 1940
BILLINGS, J. HARLAND, Professor and Head, Dept. of Mechanical Engineering, Drexel Institute, Philadelphia, Pa. 1919
BILLMYER, CARROLL D., Associate Professor of Mechanical Engineering, Rhode Island State College, Kingston, R. I. 1917

BINDER, RAYMOND C., Associate Professor of Mechanical Engineering and Fluid Mechanics, Purdue University, Lafayette, Ind. 1940
BINGHAM, LLOYD A., Assistant Professor of Electrical Engineering, University of Nebraska, Lincoln, Nebr. 1933
BIRCH, R. E., Research Engineer, Harbison-Walker Refining Co., Pittsburgh, Pa. 1942
BIRD, H. C., Professor of Civil Engineering, Duke University, Durham, N. C. 1914
BIRGE, RAYMOND T., Professor and Chairman, Dept. of Physics, University of California, Berkeley, Calif. 1939
BIRK, W. OTTO, Professor and Head, Dept. of English, University of Colorado, Boulder, Colo. (*Member of Council, 1940–43.*) 1920
BISCHOF, GUSTAVE J., Associate Professor of Mechanical Engineering, College of the City of New York, New York, N. Y. 1931
BISHOP, C. T., Associate Professor of Structural Engineering, Yale University, New Haven, Conn. 1912
BISHOP, FRANCIS F., Professor of Chemical Engineering, A. & M. College of Texas, College Station, Texas 1938
BISHOP, F. L., Professor of Physics, University of Pittsburgh, Pittsburgh, Pa. (Life Member.) (*Secretary, 1914–; Member of Council, 1912–; Secretary, Board of Investigation and Coördination, 1922–33.*) 1907
BISHOP, WALTER W., Personnel Director, Wright Aeronautical Corp., Paterson, N. J. 1940
BISSELL, G. W., Emeritus, Dean of Engineering, Michigan State College, P. O. Box 116, Monrovia, Calif. (*Member of Council, 1899–02; 1910–13.*) 1894
BIXBY, FREDERICK L., Professor and Head, Dept. of Civil Engineering, University of Nevada, Reno, Nev. 1939
BJERG, HARTWIG O., Instructor in Industrial Arts, Arizona State Teachers College, Flagstaff, Ariz. 1940
BLACK, LOREN T., Instructor in Engineering and Mathematics, Long Beach Junior College, Long Beach, Calif. 1935
BLACK, PAUL H., Associate Professor of Machine Design, Cornell University, Ithaca, N. Y. 1936
BLACK, R. M., Professor and Head, Department of Mining, University of Pittsburgh, Pittsburgh, Pa. 1912
BLACK, RALPH P., Associate Professor of Civil Engineering, Georgia School of Technology, Atlanta, Ga. 1935
BLACKBURN, HENRY W., Assistant Professor of Mechanical Engineering, Syracuse University, Syracuse, N. Y. 1928
BLAISDELL, A. H., Associate Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1921
BLAKESLEE, L. ROBERT, Assistant Professor and Acting Head, Dept. of Architectural Engineering, University of Detroit, Detroit, Mich. ... 1935
BLALOCK, GROVER C., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1918
BLENKUSH, PHILIP G., Instructor in Aeronautics, University of Detroit, Detroit, Mich. 1942
BLICKENSDERFER, HERMAN, Assistant Manager, Inca Mining and Development Co., Tirapata, Peru, S. A. 1942
BLISS, COLLINS P., Dean, Emeritus, New York University, Eton Hall, Garth Road, Scarsdale, N. Y. 1915
BLISS, HOWARD H., Head of Physics Department, Riverside Junior College, Riverside, Calif. 1923

BLISS, WARREN H., Assistant Professor of Electrical Engineering, University of Maine, Orono, Me. 1933
BLISS, WILLIAM D., Professor of Chemical Engineering, Marquette University, Milwaukee, Wis. 1926
BLISS, ZENAS R., Professor of Applied Mechanics, Brown University, Providence, R. I. **In military service** 1927
BLODGETT, HOWARD B., Acting Dean and Professor and Head, Dept. of Civil Engineering, South Dakota State College, Brookings, S. D. 1933
BLOEM, HENRY P., Instructor in Engineering, South Dakota State College, Brookings, S. D. 1940
BLUMBERG, LEO, Associate Professor of Mechanical Engineering, University of Delaware, Newark, Del. 1922
BLUMENFELD, HARRY, Instructor in Chemical Engineering, Villanova College, Villanova, Pa. 1941
BOARDMAN, H. S., President Emeritus, University of Maine, 172 Main Street, Orono, Me. (*President, 1930–31; Vice President, 1928–4; Member of Council, 1919–24; 1930–.*) 1903
BOARTS, ROBERT M., Professor and Head, Department of Chemical Engineering, University of Tennessee, Knoxville, Tenn. 1937
BOAST, WARREN B., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Iowa 1940
BOCK, LOUIS S., Instructor in Administrative Engineering, Cornell University, Ithaca, N. Y. **In military service** 1938
BOCKHORST, ROLAND W., Instructor in Applied Mathematics, Washington University, St. Louis, Mo. 1939
BODER, DAVID P., Professor of Psychology, Illinois Institute of Technology, Chicago, Ill. 1942
BOELTER, LLEWELLYN M. K., Professor of Mechanical Engineering, University of California, Berkeley, Calif. 1931
BOGARD, BEN T., Assistant Professor of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, La. 1939
BOHL, LEIGHTON T., Chairman, Division of Engineering, Professor of Civil Engineering, Brown University, Providence, R. I. 1941
BOHLIN, HOWARD G., Associate Professor of Mechanical Drawing, Assistant Curator, College of the City of New York, New York City 1935
BOLOTSKY, MAX, 1711 Commonwealth Ave., Brighton, Mass. 1939
BOLT, JAY A., Assistant Professor of Aeronautical Engineering, University of Notre Dame, Notre Dame, Ind. 1940
BOLTON, F. C., Dean of College, and Vice President, A. & M. College of Texas, College Station, Texas. (*Member of Council, 1919–22; Vice President, 1937–38.*) 1910
BOLZ, HAROLD A., Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1938
BOND, EUGENE W., Secretary-Treasurer, Bliss Electrical School, Tacomah Park, Washington, D. C. 1942
BOOHER, EDWARD E., Manager, Technical and Business Education Dept., McGraw-Hill Book Co., 330 W. 42nd St., New York City 1939
BOOMSLITER, G. P., Professor of Mechanics, West Virginia University, Morgantown, W. Va. (*Member of Council, 1934–7.*) 1912
BOON, LEONARD F., Assistant Professor of Civil Engineering, University of Minnesota, Minneapolis, Minn. 1922
BORGMAN, WILLIAM M., Assistant Professor of Mathematics, Wayne University, Detroit, Mich. 1939
BORGMANN, CARL W., Professor and Head, Dept. of Chemical Engineering, University of Colorado, Boulder, Colo. **In military service** .. 1938

Borgquist, E. S., Professor of Civil Engineering, University of Arizona, Tuscon, Ariz. 1931
Boring, Maynard M., Technical Employment, General Electric Co., Schenectady, N. Y. (*Member of Council, 1935–8.*) 1922
Bose, Surendra N., Chief Electrical Engineer, The Tata Iron and Steel Co., Ltd., Jamshedpur, via. Tatanagar, B. N. Rly., India. 1927
Boss, William, Professor Emeritus, Agricultural Engineering, University of Minnesota, St. Paul, Minn. 1925
Boston, Orlan W., Professor and Chairman, Dept. of Metal Processing, University of Michigan, Ann Arbor, Mich. 1937
Bouchard, Harry, Professor of Geodesy and Surveying, University of Michigan, Ann Arbor, Mich. 1921
Bourdelais, George A., Superintendent of Shop, Swarthmore College, Swarthmore, Pa. 1931
Bourgoin, Louis, Professor of Industrial Chemistry, Ecole Polytechnique, Montreal, Canada 1942
Bowler, Edmond W., Professor and Head, Department of Civil Engineering, University of New Hampshire, Durham, N. H. 1923
Bowles, Edward L., Professor of Electrical Communications, Massachusetts Institute of Technology, Cambridge, Mass. 1931
Bowman, Dean O., Instructor in Economics, University of Michigan, Ann Arbor, Mich. 1942
Bowman, Harry L., Professor and Head, Dept. of Civil Engineering, Drexel Institute, Philadelphia, Pa. 1922
Bowman, Henry T., Instructor in Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1929
Bowman, James H., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1931
Bowman, John G., Chancellor, University of Pittsburgh, Pittsburgh, Pa. 1923
Bowman, Richard S., c/o Dr. K. M. Bowman, Univ. Cal. Med. School, San Francisco, Calif. 1940
Bowmer, William S., Instructor in English, University of Louisville, Louisville, Ky. 1939
Boyce, Earnest, Professor of Sanitary Engineering, University of Kansas, Lawrence, Kans. **In military service** 1924
Boyd, Alfred, Professor of Civil Engineering, University of North Dakota, Grand Forks, N. D. 1909
Boyd, James E., Emeritus Professor, The Ohio State University, Columbus, O. (*Member of Council, 1911–4.*) 1907
Boynton, John E., Professor and Head, Dept. of Mechanical Engineering, Vanderbilt University, Nashville, Tenn. 1938
Boynton, Paul W., Employment Supervisor, Socony Vacuum Oil Co., Inc., 26 Broadway, New York City 1937
Brach, Earl T., College Dept., International Textbook Co., Scranton, Pa. 1942
Brackett, E. E., Professor and Chairman, Dept. of Agricultural Engineering, University of Nebraska, Lincoln, Nebr. 1923
Bradley, Frank R., Assistant Professor of Engineering Shop, Oklahoma A. & M. College, Stillwater, Okla. 1940
Bradley, James A., Dean and Associate Professor of Chemical Engineering, Newark College of Engineering, Newark, N. J. 1931
Bradshaw, George W., Associate Professor of Civil Engineering, University of Kansas, Lawrence, Kans. 1939
Bradshaw, Weldon L., Associate Professor of Architectural Engineering, Texas Technological College, Lubbock, Texas 1940

BRADT, WILBUR E., Professor and Head, Dept. of Chemistry and Chemical Engineering, University of Maine, Orono, Me. **In military service** 1937
BRAGG, EDWARD M., Professor of Naval Architecture and Marine Engineering, University of Michigan, Ann Arbor, Mich. 1940
BRAGG, FRANCIS C., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1940
BRAINARD, BOYD B., Professor of Mechanical Engineering, Kansas State College, Manhattan, Kansas 1926
BRAIS, ROGER, Assistant Professor of Chemistry, Ecole Polytechnique, Montreal, Canada 1942
BRAMER, CHARLES R., Associate Professor of Civil Engineering, North Carolina State College, Raleigh, N. Car. 1935
BRANCH, WILLIAM H., Educational Sales, Central Station Dept., General Electric Co., Schenectady, N. Y. 1936
BRANDBERRY, JOHN B., Professor of Mathematics and Engineering Mechanics, University of Toledo, Toledo, O. 1923
BRANDT, CARL G., Chairman, Dept. of English, University of Michigan, Ann Arbor, Mich. 1938
BRANIGAN, GEORGE F., Associate Professor of General Engineering and Head, Dept. Drawing, Bradley Polytechnic Institute, Peoria, Ill. ... 1929
BRATER, ERNEST F., Assistant Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. 1940
BRATTIN, CLAUD L., Professor and Head, Dept. Drawing and Design, Michigan State College, East Lansing, Mich. 1937
BRAUTLECHT, C. A., Professor of Chemistry and Chemical Engineering, University of Maine, Orono, Me. 1922
BRAY, JOHN L., Professor and Head, School of Chemical and Metallurgical Engineering, Purdue University, Lafayette, Ind. 1925
BRECKENRIDGE, ROBERT W., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1934
BREED, CHARLES B., Professor and Head, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1904
BREJLING, RALPH, Acting Principal, Brooklyn Technical High School, Brooklyn, N. Y. 1942
BRENEMAN, JOHN W., Associate Professor of Engineering Mechanics, The Pennsylvania State College, State College, Pa. 1942
BRENKE, WILLIAM C., Professor and Chairman, Dept. of Mathematics, University of Nebraska, Lincoln, Nebr. 1929
BRENNECKE, CORNELIUS G., Associate Professor of Electrical Engineering, Lehigh University, Bethlehem, Pa. 1936
BRENTON, WALTER, Chief Engineer, Portland General Electric Company, 902 Electric Building, Portland, Ore. 1934
BREWER, EVERETT L., Instructor in Chemistry, University of Maine, Orono, Me. 1941
BREWINGTON, GAIL P., Head, Dept. of Physics, Lawrence Institute of Technology, Detroit, Mich. 1941
BRIDGMAN, DONALD S., Staff Assistant in Personnel Relations, American Tel. & Tel. Co., 195 Broadway, New York City 1939
BRIERLEY, JOHN R., Executive Alumni Secretary, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1936
BRIGGS, HERMAN B., Professor of Engineering Drawing and Descriptive Geometry, North Carolina State College, Raleigh, N. C. 1937
BRIGHT, RICHARD, Assistant Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. 1942

BRINKER, RUSSELL C., Assistant Professor of Structural Engineering, University of Minnesota, Minneapolis, Minn. **In military service** .. 1931

BRINKER, WILLIAM E., Associate Professor and Chairman, Dept. of Chemical Engineering, Northwestern Technological Institute, Evanston, Ill. 1939

BRISTOL, RUTH A., Secretary-Librarian, Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H. 1941

BROCK, GENE H., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas 1942

BROMILOW, FRANK, Assistant Professor of Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. 1939

BRONWELL, ARTHUR B., Assistant Professor of Electrical Engineering, Northwestern Technological Institute, Evanston, Ill. 1937

BROOKE, W. E., Professor and Head of Department of Mathematics and Mechanics, Dept. of Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. (*Member of Council, 1924–7.*) .. 1902

BROOKS, J. ANSEL, Professor of Industrial Engineering, Newark College of Engineering, Retired, Madison, Conn. 1904

BROOKS, MORGAN, Professor Emeritus of Electrical Engineering, University of Illinois; 117 E. French, San Antonio, Texas 1899

BROTHERS, LEROY A., Assistant Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937

BROWN, ARTHUR S., Assistant Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. 1930

BROWN, AUBREY I., Professor and Acting Head, Dept. Heating and Ventilating, The Ohio State University, Columbus, O. 1914

BROWN, CARL W., Assistant Professor of Electrical Engineering, University of Wyoming, Laramie, Wyo. 1939

BROWN, CLEO A., Head, English and Coordination Department, General Motors Institute of Technology, Flint, Mich. 1931

BROWN, EDWARD C., Assistant Professor of Mathematics, Worcester Polytechnic Institute, Worcester, Mass. 1922

BROWN, EDWARD S., Assistant Professor of Civil Engineering, Dartmouth College, Hanover, N. H. 1937

BROWN, FRANK N. M., Associate Professor and Head, Dept. Aeronautical Engineering, University of Notre Dame, Notre Dame, Ind. 1939

BROWN, FREDERICK L., Professor of Physics, University of Virginia, University, Va. 1926

BROWN, F. L., Professor of Applied Mechanics, University of Kansas, Lawrence, Kans. 1915

BROWN, GEORGE G., Professor of Chemical Engineering, Chairman, Dept. Chem. and Met. Eng., University of Michigan, Ann Arbor, Mich. 1939

BROWN, HUGH A., Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1928

BROWN, LYNN T., Associate Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1931

BROWN, RALPH E., Associate Professor of Mechanical Engineering, Rhode Island State College, Kingston, R. I. 1924

BROWN, ROBERT Q., Associate Professor of General Engineering, University of Washington, Seattle, Wash. 1941

BROWN, R. T., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. 1937

BROWN, T. C., Assistant Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1937

BROWN, WALTER F., Professor of Electrical Engineering, University of Toledo, Toledo, Ohio 1941
BROWN, WESLEY B., Head, Development Lab., Electric Controller & Mfg. Co., Cleveland, Ohio 1926
BROWNE, WM. HAND, JR., Professor and Head, Dept. of Electrical Engineering, North Carolina College of A. & E., State College Station, Raleigh, N. C. (*Member of Council, 1916–9.*) 1899
BROZEN, YALE, Assistant Professor of Industrial Engineering, Illinois Institute of Technology, Chicago, Ill. 1942
BRUBAKER, WM. F., Associate Professor of Engineering Drawing and Machine Design, University of Colorado, Boulder, Colo. 1924
BRUMFIELD, RAY C., Associate Professor of Civil Engineering, Cooper Union, New York City 1929
BRUNOTTO, LORENZO, Librarian, Ecole Polytechnique, Montreal, Canada 1942
BRUST, ALVIN W., Associate Professor of Civil Engineering, Washington University, St. Louis, Mo. 1941
BRYANS, W. R., Assistant Dean, Professor of Mechanics, New York University, New York, N. Y. 1908
BRYANT, J. M., Professor and Head, Dept. of Electrical Engineering, University of Minnesota, Minneapolis, Minn. (*Member of Council, 1927–30.*) 1910
BUBB, FRANK W., Professor of Applied Mathematics, Washington University, St. Louis, Mo. 1938
BUCHAN, ALEXANDER M., Assistant Professor of English, Washington University, St. Louis, Mo. 1939
BUCHANAN, JESSE E., Dean, College of Engineering, and Director, Eng. Experiment Sta., University of Idaho, Moscow, Idaho. **In military service** 1927
BUCHANAN, ROY O., Associate Professor of Electrical Engineering, University of Vermont, Burlington, Vt. 1922
BUCHER, PAUL, Professor of Steam Engineering, The Ohio State University, Columbus, Ohio 1920
BUCK, A. M., Engineering Editor, *Transit Journal*, 330 West 42 St., New York, N. Y. 1910
BUCK, CARSON P., Assistant Professor of Engineering Drawing, University of Notre Dame, Notre Dame, Ind. 1939
BUCKINGHAM, EARLE, Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1932
BUCKY, P. B., Associate Professor of Mining, Columbia University, New York City 1940
BUDENHOLZER, ROLAND A., Instructor in Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1941
BUDGE, WILLIAM E., Professor of Mining Engineering, University of North Dakota, Grand Forks, N. D. 1938
BUECHE, H. S., Professor of Electrical Engineering, Villanova College, Villanova, Pa. 1932
BUERER, WAYNE W., Assistant Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1939
BUKOVSKY, PAUL N., Assistant Professor of Mechanism and Engineering Drawing, University of Michigan, Ann Arbor, Mich. 1930
BULLARD, JAMES A., Professor of Mechanics and Mathematics, University of Vermont, Burlington, Vt. 1927
BULLEN, CHARLES V., Professor and Head, Department of Electrical Engineering, Texas Technological College, Lubbock, Texas 1934

BULLINGER, CLARENCE E., Professor and Head, Dept. of Industrial Engineering, The Pennsylvania State College, State College, Pa. 1925
BULLOCK, ROBERT C., Associate Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1937
BUNKER, JOHN W. M., Dean, Graduate School, Massachusetts Institute of Technology, Cambridge, Mass. 1940
BURDELL, EDWIN S., Director, Cooper Union, New York City 1937
BURDEN, HARRY P., Dean, Engineering School, and Professor of Sanitary Engineering, Tufts College, Medford, Mass. 1921
BUREAU, E. A., Professor and Head, Dept. of Electrical Engineering, University of Kentucky, Lexington, Ky. 1923
BURGLAND, W. P., Manager, Exhibits Division, General Publicity Dept., Union Carbide Co., 205 E. 42nd St., New York City 1936
BURINGTON, RICHARD S., Associate Professor of Mathematics, Case School of Applied Science, Cleveland, Ohio. **In military service** 1934
BURKLAND, CARL E., Professor of English, University of Michigan, Ann Arbor, Mich. 1940
BURLEY, JOHN W., Head, Machine Dept., Pratt Institute, Brooklyn, N. Y. 1926
BURMISTER, DONALD M., Assistant Profesor of Civil Engineering, Columbia University, New York City 1935
BURNS, GEORGE W., Assistant Dean of Engineering, Professor of Coordination, University of Cincinnati, Cincinnati, Ohio 1931
BURR, ARTHUR H., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. 1941
BURSLEY, JOSEPH A., Professor of Mechanical Engineering, Dean of Students, University of Michigan, Ann Arbor, Mich. 1910
BUSH, B. H., Dean of Engineering, Fenn College, Cleveland, Ohio. **In military service** 1935
BUSH, VANNEVAR, President, Carnegie Institution of Washington, D. C... 1923
BUSSE, FRANK A., Personnel Manager, Falstrom Co., Passaic, N. J. 1937
BUTLER, G. M., Dean, College of Mines and Engineering, Director, Arizona Bureau of Mines, University of Arizona, Tucson, Ariz. (*Member of Council, 1924–7.*) 1916
BUTLER, JOE B., Professor of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Mo. 1922
BUTLER, ROBERT S., Instructor in Civil Engineering, Yale University, New Haven, Conn. 1937
BUTTERFIELD, ARTHUR D., Professor of Mathematics and Geodesy, University of Vermont, Burlington, Vt. 1908
BUTTERFIELD, THOMAS E., Professor of Heat Power Engineering, Lehigh University, Bethlehem, Pa. 1920
BUTTS, ALLISON, Professor of Electrometallurgy, Lehigh University, Bethlehem, Pa. 1934
CADE, C. MARSHALL, Professor of Civil Engineering, Michigan State College, East Lansing, Mich. **In military service** 1937
CADY, LOUIS C., Professor and Head, Dept. of Chemistry and Chemical Engineering, University of Idaho, Moscow, Ida. 1931
CAGE, JOHN M., Associate Professor of Electrical Engineering, University of Colorado, Boulder, Colo. 1942
CALDWELL, FRANK C., Professor Emeritus, The Ohio State University, Columbus, O. (*Member of Council, 1905–8.*) 1897
CALHOON, FLOYD N., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1940
CALLAGHAN, JOSEPH C., Assistant Professor of English and Speech, Lehigh University, Bethlehem, Pa. 1936

CALLEN, ALFRED C., Dean, College of Engineering, Professor and Head, Department of Mining Engineering, Lehigh University, Bethlehem, Pa. (*Member of Council, 1941–4.*) 1926
CALVERT, JOHN F., Professor and Chairman, Dept. of Electrical Engineering, Northwestern Technological Institute, Evanston, Ill. 1937
CAMERON, HUGH S., Instructor in Mechanical Technology, Pratt Institute, Brooklyn, N. Y. 1928
CAMP, CECIL S., Associate Professor of Hydraulic Engineering, University of Tennessee, Knoxville, Tenn. 1936
CAMP, THOMAS R., Associate Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1936
CAMPBELL, JESSE M., Assistant Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. 1931
CAMPBELL, JOHN S., Instructor, Pasadena Junior College, Pasadena, Calif. 1942
CAMPBELL, ROBERT M., Professor of Ceramic Technology, New York State College of Ceramics at Alfred University, Alfred, N. Y. 1937
CAMPBELL, WM. B., Associate Professor of Mechanical Engineering, Pennsylvania Military College, Chester, Pa. 1939
CANAVACIOL, FRANK E., Associate Professor of Electrical Communications, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1928
CANDEE, F. W., Assistant Professor of Mechanical Engineering, Washington State College, Pullman, Wash. 1924
CANFIELD, DONALD T., Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1925
CANNON, JOSEPH H., Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1940
CAPARO, JOSE A., Professor of Electrical Engineering, University of Notre Name, Notre Dame, Ind. 1939
CARDIN, C. J., Professor and Head, Dept. of General Engineering, North Central College, Naperville, Ill. 1937
CARDOSO, ANTONIO C., Assistant Professor of Electrical Engineering, University of S. Paulo, S. Paulo, Brasil, S. A. 1935
CAREY, CLIFTON O., Associate Professor of Geodesy and Surveying, University of Michigan, Ann Arbor, Mich. 1941
CAREY, ROBERT H., Assistant Professor of Engineering Mechanics, The Pennsylvania State College, State College, Pa. 1938
CARLSON, WALTER W., Professor and Head, Dept. of Shop Practice, Kansas State College, Manhattan, Kans. 1912
CARLTON, ERNEST W., Professor of Structural Engineering, Missouri School of Mines, Rolla, Mo. 1937
CARMICHAEL, COLIN, Associate Editor, Machine Design, Penton Pub. Co., Cleveland, Ohio 1934
CARPENTER, ARTHUR HOWE, Associate Professor of Metallurgy, Illinois Institute of Technology, Chicago, Ill. 1935
CARPENTER, EDWARD L., Assistant Professor of Mechanical Engineering Rhode Island State College, Kingston, R. I. 1922
CARPENTER, JAMES H., Instructor in Mechanical Engineering, Syracuse University, Syracuse, N. Y. 1941
CARPENTER, JAY A., Director, Mackay School of Mines, University of Nevada, Reno, Nev. 1934
CARPENTER, OTTO, Supervisor of College Relations, Western Electric Co., 195 Broadway, New York City 1936
CARPENTER, SAMUEL T., Associate Professor of Civil Engineering, Swarthmore College, Swarthmore, Pa. 1936

CARR, ARTHUR R., Dean, College of Engineering, Wayne University, Detroit, Mich. 1927

CARR, CLIFFORD C., Supervisor, Head, Dept. of Electrical Engineering, Pratt Institute, Brooklyn, N. Y. 1926

CARR, HENRY M., Associate Professor and Head, Dept. of Industrial Engineering, University of Alabama, University, Ala. 1940

CARRUTHERS, JOHN L., Professor of Ceramic Engineering, The Ohio State University, Columbus, Ohio 1929

CARSON, CHARLES M., Professor and Head, Dept. of Chemistry and Chemical Engineering, Michigan College of M. & T., Houghton, Mich. 1937

CARSON, GORDON B., Associate Professor of Industrial Engineering, Case School of Applied Science, Cleveland, Ohio 1934

CARSON, WILLIAM H., Dean, College of Engineering, University of Oklahoma, Norman, Okla. 1942

CARTER, CLIFTON C., Professor of Natural and Experimental Philosophy, U. S. Military Academy, West Point, N. Y. **In military service** .. 1928

CARTER, HAROLD S., Professor of Civil Engineering, Utah Agricultural College, Logan, Utah 1924

CARTIER, LEONARD, Assistant Professor of Hydraulics, Ecole Polytechnique, Montreal, Canada 1942

CARTLAND, FRED W., Assistant Professor of Electrical Engineering, Michigan College of M. & T., Houghton, Mich. 1938

CARVIN, FRANK D., Professor and Head, Dept. of Mechanical Engineering, Newark College of Engineering, Newark, N. J. 1925

CASAGRANDE, ARTHUR, Associate Professor of Civil Engineering, Harvard University, Cambridge, Mass. 1935

CASBERG, CARL H., Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1933

CASE, ALLANDO A., Supt. of Shop Labs., Georgia School of Technology, Atlanta, Ga. 1932

CASE, GEO. W., Dean, College of Technology, Director, Engineering Experiment Station, University of New Hampshire, Durham, N. H. (Director, E. S. M. W. T., U. S. Office of Education, Washington, D. C.) (*Member of Council, 1934–7; Vice President, 1938–9.*) 1914

CASSEL, ELLWOOD B., Assistant Professor of Engineering Drawing, The Pennsylvania State College, State College, Pa. 1937

CASSELL, WALLACE L., Professor of Electrical Engineering, Iowa State College, Ames, Iowa 1939

CASTLEMAN, FRANCIS L., JR., Professor and Head, Dept. of Civil Engineering, University of Connecticut, Storrs, Conn. 1938

CASTLEMAN, JOHN R., Associate Professor of Engineering Drawing, Virginia Polytechnic Institute, Blacksburg, Va. 1930

CATHER, CARL H., Associate Professor of Mechanics, West Virginia University, Morgantown, W. Va. 1936

CATHER, HAROLD M., Associate Professor of Power Engineering, West Virginia University, Morgantown, W. Va. 1937

CATON, JOHN J., Director, Chrysler Institute of Engineering, Detroit, Mich. 1942

CAUGHEY, R. A., Professor of Structural Engineering, Iowa State College, Ames, Iowa 1911

CAVERLEY, L. C., Assistant Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn. 1927

CAYWOOD, THOMAS G., Associate Professor of Mechanical Engineering, State University of Iowa, Iowa City, Iowa 1936

CECIL, JESSE B., Instructor in Engineering Mechanics, University of Nebraska, Lincoln, Nebr. 1940
CEJKA, JOSEPH B., Assistant Professor of Mechanical Engineering, Rutgers University, New Brunswick, N. J. 1938
CELL, JOHN W., Associate Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1936
CHADERTON, JULIAN C., Instructor in Civil Engineering, University of Detroit, Detroit, Mich. 1942
CHALLENDER, RALPH T., Professor of General Engineering, Montana State College, Bozeman, Mont. 1925
CHAMBERLAIN, JOSEPH B., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1937
CHAMBERLAIN, JOS. J., Associate Professor of Civil Engineering, University of Dayton, Dayton, Ohio 1940
CHAMBERLAIN, MARGUERITE, Eastman Librarian, Massachusetts Institute of Technology, Cambridge, Mass. 1941
CHAMBERLIN, STEPHEN J., Assistant Professor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa 1935
CHAMBERS, ALVIN L., Assistant Professor of Testing Materials, University of Kentucky, Lexington, Ky. 1938
CHAMBERS, SHERMAN D., Professor of Applied Mechanics, Purdue University, Lafayette, Ind. 1921
CHAMPION, ROBERT L., Instructor in Drawing and Design, Michigan State College, East Lansing, Mich. 1939
CHANDLER, E. F., Professor of Civil Engineering and Dean Emeritus, College of Engineering, University of North Dakota, University, N. D. 1907
CHAPMAN, LAURENCE B., Professor of Marine Transportation and Marine Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1942
CHAPMAN, ROBERT G., Associate Professor and Head, Dept. of Mechanical Engineering, University of Vermont, Burlington, Vt. 1939
CHASE, CHARLES H., Professor of Steam Engineering, Emeritus, Tufts College, Medford, Mass. 1935
CHEATHAM, JAMES C., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. **In military service** 1941
CHEDSEY, WILLIAM R., Consulting Engineer, 483 W. 7 Ave., Columbus, Ohio 1937
CHEEK, FRANK J., JR., Professor of Sanitary Engineering, University of Kentucky, Lexington, Ky. 1924
CHERRY, CARLTON E., Instructor in Engineering and Mathematics, Marin Junior College, Kentfield, Calif. 1931
CHERRY, FLOYD H., Associate Professor of Mechanical Engineering, University of California, Berkeley, Calif. 1930
CHESTERMAN, FRANCIS J., Vice President, Bell Telephone Co. of Pa., Philadelphia, Pa. 1936
CHILLMAN, EDWARD F., Emeritus Professor of Drawing, Rensselaer Polytechnic Institute, Troy, N. Y. 1920
CHILTON, THOMAS H., Director, Technical Div., Engineering Dept., E. I. duPont de Nemours & Co., Wilmington, Del. 1939
CHRISTENSEN, N. A., Dean of Engineering, Colorado State College, Ft. Collins, Colo. 1938
CHRISTIE, A. G., Professor of Mechanical Engineering, The Johns Hopkins University, Baltimore, Md. 1923

CHURCH, A. H., Associate Professor of Machine Design, New York University, New York City 1940
CHURCH, EDWIN F., JR., Professor and Head, Dept. of Mechanical Engineering, The Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1910
CHURCH, JAMES M., Assistant Professor of Chemical Engineering, Columbia University, New York City 1941
CIRCÉ, ARMAND, Dean of Engineering, Ecole Polytechnique, Montreal, Canada 1930
CLARK, ADRIAN N., Technical Editing, D. Van Nostrand Co., 250 Fourth Ave., New York City 1941
CLARK, DAVIS S., Assistant Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1932
CLARK, DONALD S., Assistant Professor of Mechanical Engineering, California Institute of Technology, Pasadena, Calif. 1942
CLARK, EDGAR C., Associate Professor of Mechanics, The Ohio State University, Columbus, Ohio 1928
CLARK, EDWIN E., Professor of Electrical Engineering, South Dakota School of Mines, Rapid City, S. D. 1922
CLARK, GEORGE W., Associate Professor of Civil Engineering, Ohio University, Athens, Ohio 1938
CLARK, JAMES C., Professor of Electrical Engineering, University of Arizona, Tucson, Ariz. 1912
CLARK, LEROY W., Professor and Head, Dept. of Mechanics, Rensselaer Polytechnic Institute, Troy, N. Y. 1922
CLARK, ROY E., Assistant Professor of Heat Power Engineering, Cornell University, Ithaca, N. Y. 1937
CLARKE, CLARENCE L., Dean of Arts and Science, Illinois Institute of Technology, Chicago, Ill. 1939
CLARKE, ELWYN L., Professor and Head, Dept. of Civil Engineering, Clemson College, Clemson College, S. C. 1921
CLARKSON, JOHN M., Associate Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1936
CLAYTON, WALTER C., Coordinator, Engineering Education, Lockheed Aircraft Corp., Burbank, Calif. 1941
CLEARY, STEPHEN F., Associate Professor of Engineering Drawing, Cornell University, Ithaca, N. Y. 1932
CLEGHORN, M. P., Professor and Head, Dept. of Mechanical Engineering, Iowa State College, Ames, Ia. 1910
CLELAND, SAMUEL M., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas 1942
CLEMENS, GEORGE J., Instructor in Drafting, College of the City of New York, New York City 1940
CLEMENT, WILLIAM B., Assistant Professor of Mechanical Engineering, The Citadel, Charleston, S. C. 1940
CLEMENTS, S. EUGENE, Assistant Professor of Electrical Engineering, University of Kansas, Lawrence, Kansas. **In military service** 1940
CLEVELAND, LAURENCE F., Associate Professor of Electrical Engineering, Northeastern University, Boston, Mass. 1930
CLICKENER, CORWIN K., Structural Engineer, Sargent & Lundy, Chicago, Ill. 1939
CLOKE, PAUL, Dean, College of Technology, University of Maine, Orono, Me. (*Vice President, 1932–33; Member of Council, 1928–31.*) 1919
CLOUD, WILLIAM F., Professor of Petroleum Engineering, University of Oklahoma, Norman, Okla. 1938

CLOUSE, JOHN H., Professor of Physics, Director of Engineering Studies, University of Miami, 6012 43 Ave., Hyattsville, Md. 1927
CLOWER, JAMES I., Professor of Machine Design, Virginia Polytechnic Institute, Blacksburg, Va. 1937
CLYDE, GEORGE D., Dean, School of Engineering, Utah State Agricultural College, Logan, Utah 1937
COATES, JESSE, Assistant Professor of Chemical Engineering, Louisiana State University, University, La. 1939
COBB, CHARLES N., Assistant Professor of Industrial Engineering and Shops, Alabama Polytechnic Institute, Auburn, Ala. 1938
COBINE, JAMES D., Assistant Professor of Electrical Engineering, Harvard University, Cambridge, Mass. 1938
COBLEIGH, W. M., Acting President, Montana State College, Bozeman, Mont. (*Member of Council, 1932–35.*) 1929
COBURN, JAMES M., Assistant Professor of Aeronautics, New York University, New York City 1938
COBURN, THEODORE, Western Representative, John Wiley and Sons, Inc., 440 Fourth Avenue, New York City 1925
COCKRELL, WAYNE L., Assistant Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. **In military service** 1938
CODDINGTON, E. F., Emeritus Professor of Geodetic Engineering, The Ohio State University, Columbus, Ohio. 1911
CODWISE, HENRY R., Professor of Railroad Engineering and Surveying, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1914
COFFINBERRY, ARTHUR S., Assistant Professor of Metallurgy, University of Notre Dame, Notre Dame, Ind. 1941
COIE, JOHN S., Assistant Professor of English, Washington State College, Pullman, Wash. 1936
COLBERT, JULES P., Associate Professor of Engineering Mechanics, Freshman Advisor, University of Nebraska, Lincoln, Nebr. 1935
COLBURN, ALLAN P., Professor of Chemical Engineering, University of Delaware, Newark, Del. 1938
COLE, R. W., Mechanical Engineer, Stone & Webster Eng. Co., Boston, Mass. 1939
COLLARD, ARTHUR A., Instructor in Mechanical Technology, Pratt Institute, Brooklyn, N. Y. 1938
COLLIER, IRA L., Assistant Professor of Civil Engineering, University of Washington, Seattle, Wash. 1924
COLLINS, BASIL K., Instructor in Industrial Engineering and Shops, Alabama Polytechnic Institute, Auburn, Ala. **In military service** 1935
COLLINS, GEORGE B., Associate Professor of Physics, University of Notre Dame, Notre Dame, Ind. 1939
COLLINS, W. LEIGHTON, Assistant Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. **In military service** 1932
COLLYER, NORMAN, Assistant Secretary, Paramount Pictures, Inc., Paramount Building, Times Square, New York City 1919
COLSTON, ALBERT L., Principal, Brooklyn Technical High School, 49 Flatbush Ave., Ext., Brooklyn, N. Y. 1926
COLVERT, WILLIAM W., Associate Professor of Physics, Illinois Institute of Technology, Chicago, Ill. 1935
COLVIN, CHARLES H., Director, School of Aeronautics, Coordinator of Research, New York University, New York City 1941
COLVIN, FRED H., Consultant, Navy Bureau of Aeronautics, 2000 F St., N.W., Washington, D. C. 1942

Colyer, Edward E., Professor and Head, Dept. of Mathematics, Fort Hays Kansas State College, Hays, Kansas 1939

Comins, Harrison D., Assistant Professor of Civil Engineering, University of Missouri, Columbia, Mo. 1937

Compton, Horace B., Assistant Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. In military service 1934

Compton, Karl T., President, Massachusetts Institute of Technology, Cambridge, Mass. (*Member of Council, 1933–36, 1937–; Vice President, 1937–38; President, 1938–39.*) **1929**

Comstock, E. H., Professor of Mining, University of Minnesota, Minneapolis, Minn. 1938

Condit, Kenneth H., Dean, School of Engineering, Professor of Mechanical Engineering, Princeton University, Princeton, N. J. (*Member of Council, 1939–42.*) 1937

Condon, Edward V., Associate Director of Research, Westinghouse E. & M. Co., East Pittsburgh, Pa. 1941

Conkling, Leon D., Professor of Civil Engineering, Montana State College, Bozeman, Mont. **In military service** 1933

Conley, Hugh G., Instructor in Civil Engineering, University of Southern California, Los Angeles, Calif. 1939

Conley, William J., Professor and Acting Chairman, Dept. of Applied Mechanics, University of Rochester, Rochester, N. Y. 1929

Conlon, Emerson W., Associate Professor of Aeronautical Engineering, University of Michigan, Ann Arbor, Mich. **In military service** 1940

Conner, N. White, Associate Professor of Engineering Mechanics, North Carolina State College, Raleigh, N. C. 1931

Connolly, Joseph P., President and Professor of Geology, South Dakota School of Mines, Rapid City, S. D. 1937

Conover, Lawrence J., Associate Professor of Electrical Engineering, Lafayette College, Easton, Pa. 1942

Conrad, Albert G., Associate Professor of Electrical Engineering, Yale University, New Haven, Conn. 1929

Conrad, Frank H., Associate Professor of Chemical Engineering, Missouri School of Mines, Rolla, Mo. 1938

Conrad, L. E., Professor and Head, Dept. of Civil Engineering, Kansas State College, Manhattan, Kansas. (*Vice President, 1940–1; Member of Council, 1931–4.*) 1908

Conroe, Irwin A., Assistant Commissioner for Professional Education, State Dept. of Education, Albany, N. Y. 1942

Constant, F. H., Professor of Civil Engineering, Emeritus, Princeton University, Princeton, N. J. (*Vice President, 1915–6; Member of Council, 1909–12.*) 1896

Coogan, Charles H., Jr., Assistant Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn. 1931

Cook, A. L., Director, School of Science and Technology, Pratt Institute, Brooklyn, N. Y. 1913

Cook, Rudyard M., Assistant Professor of Engineering Mechanics, Louisiana State University, Baton Rouge, La. 1941

Cooke, Henry C., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. 1940

Cooke, Nelson M., Officer in charge Primary School, Naval Research Laboratory, Anacostia, D. C. In military service 1942

Cooke, S. P., Assistant Professor of Electrical Engineering, Brown University, Providence, R. I. 1939

COOLBAUGH, MELVILLE F., President, Colorado School of Mines, Golden, Colo. 1925
COOLEY, ALBERT M., Associate Professor of Chemical Engineering, University of North Dakota, Grand Forks, N. D. 1935
COOLEY, HENRY B., Assistant Professor of Economics and Business Administration, West Virginia University, Morgantown, W. Va. 1938
COOLEY, M. E., Dean Emeritus, University of Michigan, Ann Arbor, Mich. *(President, 1920–1; Vice President, 1908–9; Member of Council, 1893–4; 1907–10; 1920–; Member, Board of Investigation and Coordinations, 1922–8.)* 1893
COONRADT, ARTHUR C., Professor and Chairman, Dept. of Mechanical Engineering, New York University, New York City 1932
COONS, KENNETH W., Professor and Head, Dept. of Chemical Engineering, University of Alabama, Tuscaloosa, Ala. 1939
COOPER, ALBERT H., Associate Professor of Chemical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. **In military service** .. 1936
COOPER, CHARLES D., Associate Professor of Engineering Drawing, The Ohio State University, Columbus, Ohio 1942
COOPER, FRANK L., Instructor in Physics, Yale University, New Haven, Conn. 1912
COOPER, LINTON L., Professor and Head, Dept. of Mechanical Drawing, Louisiana State University, University, La. 1934
COOVER, MERVIN S., Professor and Head, Department of Electrical Engineering, Iowa State College, Ames, Iowa 1923
COPE, RALPH L., Assistant Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1939
COPE, WILLIAM J., Professor and Head, Dept. of Mechanical Engineering, University of Utah, Salt Lake City, Utah 1937
COPELAND, PAUL L., Professor of Physics, Illinois Institute of Technology, Chicago, Ill. 1941
COPELAND, ROBERT M., Lieutenant Colonel, Corps of Engineers, U. S. Army, Engineer, Replacement Center, Ft. Leonard Wood, Mo. 1935
COPPERSMITH, C. W., Associate Professor of Engineering Drawing, Case School of Applied Science, Cleveland, O. 1915
CORCORAN, GEORGE F., Professor and Chairman, Dept. of Electrical Engineering, University of Maryland, College Park, Md. 1926
CORNELL, W. R., Professor of Mechanics of Engineering, Cornell University, Ithaca, N. Y. 1910
CORY, MERTON M., Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. 1937
COSTA, JOHN J., Professor of Civil Engineering, Manhattan College, New York City 1927
COTHERN, LELAND I., Professor of Mining Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1939
COTTINGHAM, WILLARD S., Associate Professor of Structural Engineering, University of Wisconsin, Madison, Wis. 1937
COULL, JAMES, Professor and Head, Dept. of Chemical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1939
COUNTRYMAN, M. ALDEN, Assistant Professor of Physics, Illinois Institute of Technology, Chicago, Ill. 1939
COVAN, JACK P., Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill. 1939
COVER, GERALD M., Associate Professor of Metallurgical Engineering, Case School of Applied Science, Cleveland, Ohio 1939

COWGILL, ALLEN P., Assistant Professor of Applied Mathematics, Syracuse University, Syracuse, N. Y. 1941
COWIE, ALEXANDER, Instructor in Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1933
COWLES, W. H. H., Head, Department of Mathematics and English, Pratt Institute, Brooklyn, N. Y. 1929
COX, GLEN N., Professor of Mechanics and Hydraulics, Louisiana State University, University, La. 1935
CRABTREE, FREDERICK H., Assistant Professor of Civil Engineering, Tufts College, Medford, Mass. **In military service** 1934
CRABTREE, KENNETH G., Assistant Professor of Electrical Engineering, University of Maine, Orono, Me. 1942
CRAFT, BENJAMIN C., Professor and Head, Dept. of Petroleum Engineering, Louisiana State University, University, La. 1935
CRAIG, HOMER V., Associate Professor of Applied Mathematics and Astronomy, University of Texas, Austin, Texas 1942
CRANE, WILLIAM G., Assistant Professor of English, College of the City of New York, New York City 1940
CRAWFORD, CHARLES W., Professor and Head, Department of Mechanical Engineering, A. & M. College of Texas, College Station, Tex. 1923
CRAWFORD, IVAN C., Dean, School of Engineering, Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. (*Member of Council, 1929–32; Vice President, 1936–37.*) 1913
CRAWFORD, I. C., JR., Instructor in Civil Engineering, Rhode Island State College, Kingston, R. I. **In military service** 1939
CRAWFORD, T. STEPHEN, Professor and Head, Dept. of Chemical Engineering, Rhode Island State College, Kingston, R. I. 1936
CRAWFORD, W. W., Associate Professor of Civil Engineering, Kansas State College, Manhattan, Kans. 1926
CREAGER, PAUL S., Associate Professor of Electrical Engineering, Rutgers University, New Brunswick, N. J. 1923
CREAMER, WALTER J., Professor of Communication Engineering, University of Maine, Orono, Me. 1922
CREDLE, ALEXANDER B., Assistant Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. 1935
CREEK, HERBERT L., Professor and Head, Dept. of English and Speech, Purdue University, Lafayette, Ind. 1922
CREESE, JAMES, Vice President and Treasurer, Stevens Institute of Technology, Hoboken, N. J. 1934
CREESE, MYRON, Professor and Head, Dept. of Electrical Engineering, University of Maryland, College Park, Md. 1941
CROFOOT, GEORGE E., Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1919
CROFT, HUBER O., Professor and Head, Mechanical Engineering Department, State University of Iowa, Iowa City, Iowa 1931
CROMER, ORVILLE C., Assistant Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1940
CROMWELL, PAUL C., Assistant Professor of Electrical Engineering, New York University, New York City 1935
CROSBY, LEMUEL S., General Personnel Supervisor, Long Lines Dept., American Telephone and Telegraph Co., 32 6th Ave., New York, N. Y. 1929
CROSS, HARDY, Professor and Chairman, Dept. of Civil Engineering, Yale University, New Haven, Conn. 1912

CROSSMAN, RALPH S., Associate in General Engineering Drawing, University of Illinois, Urbana, Ill. 1919
CROTHERS, H. M., Dean, Division of Engineering, Professor of Electrical Engineering, South Dakota State College, Brookings, S. D. (E. S. M. D. T., U. S. Office of Education, Washington, D. C.) 1923
CROUCH, JOEL E., Assistant Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. 1940
CROUCH, W. GEORGE, Assistant Professor of English, University of Pittsburgh, Pittsburgh, Pa. 1940
CROUT, PRESCOTT D., Assistant Professor of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. 1937
CROWDER, BERT A., Instructor in , University of Minnesota, Minneapolis, Minn. 1941
CUDWORTH, JAMES R., Director, School of Mines, Professor of Mining Engineering, University of Alabama, University, Ala. 1934
CULLIMORE, ALLAN R., President, Newark College of Engineering, Newark, N. J. (*Member of Council, 1940–43.*) 1914
CULVER, EDWARD G., Teacher of Drawing, Bay City Junior College, Bay City, Mich. 1941
CUMMINGS, HAROLD N., Vice President, Newark College of Engineering, Newark, N. J. 1930
CUNNINGHAM, CHARLES W., Instructor in Civil Engineering, College of the City of New York, New York City, N. Y. 1936
CUNNINGHAM, JOHN B., Professor of Metallurgy and Ore Dressing, University of Arizona, Tucson, Ariz. 1936
CURRY, WALTER A., Assistant Professor of Electrical Engineering, Columbia University, New York City 1928
CURTIS, DONALD D., Professor of Mechanics and Hydraulics, Clemson College, Clemson College, S. C. 1923
CURTIS, HARRY A., Dean of Engineering, University of Missouri, Columbia, Mo. (*Member of Council, 1940–43.*) 1938
CUSHMAN, PAUL A., Metallurgist and Head, Experimental Dept., McGill Mfg. Co., 803 Brown St., Valparaiso, Ind. 1922
CUTLER, A. S., Professor of Railway Engineering, University of Minnesota, Minneapolis, Minn. 1926
CUTSHALL, CHESTER S., Professor of Applied Mechanics, Purdue University, Lafayette, Ind. 1941
DAASCH, FRANCIS J., Associate Professor of Mechanical Engineering, University of Arkansas, Fayetteville, Ark. 1937
DAASCH, HARRY L., Professor and Head, Dept. of Mechanical Engineering, University of Vermont, Burlington, Vt. 1934
DACE, FRED E., Associate Professor and Head, Dept. of Electrical Engineering; Director of Evening Division, Bradley Polytechnic Institute, Peoria, Ill. 1942
DAGGETT, P. H., Dean, College of Engineering, Rutgers University, New Brunswick, N. J. (*Member of Council, 1921–4.*) 1910
DAHL, OTTO G. C., Engineer, Jackson & Moreland, Engineers, 31 St. James Ave., Boston, Mass. 1932
DAHLENE, OSCAR, Professor and Head, Dept. of Mechanics, University of Alabama, University, Ala. 1936
DAKE, EARL D., Professor of Civil Engineering, South Dakota School of Mines, Rapid City, S. D. 1940
DALE, R. BURDETTE, Consulting Management and Mechanical Engineer, 25 Broad St., New York City 1921

DALEY, JOHN L., Assistant Professor of Electrical Engineering, Yale University, New Haven, Conn. 1940
DANA, FOREST C., Professor of General Engineering, Iowa State College, Ames, Iowa 1923
DANIELS, JOSEPH, Professor of Mining Engineering and Metallurgy, University of Washington, Seattle, Wash. 1910
DANIELS, WALTER T., Director of Mechanic Arts, Southern University and A. & M. College, Scotlandville, La. 1942
DAUGHERTY, ROBERT L., Professor of Mechanical and Hydraulic Engineering, California Institute of Technology, Pasadena, Calif. 1942
DAVEY, HAROLD M., Instructor in Social Science, Illinois Institute of Technology, Chicago, Ill. 1941
DAVIDSON, ARTHUR J., Instructor in Civil Engineering, University of Idaho, Moscow, Idaho. **In military service** 1940
DAVIDSON, J. BROWNLEE, Professor and Head, Department of Agricultural Engineering, Iowa State College, Ames, Iowa 1915
DAVIES, C. E., Secretary, American Society of Mechanical Engineers, 29 West 39th Street, New York City. (*Member of Council, 1934–7.*) **In military service** 1925
DAVIS, ALTON F., Secretary, The James F. Lincoln Arc Welding Foundation, 12818 Coit Road, Cleveland, Ohio 1942
DAVIS, CALVIN V., Project Engineer, Fontana Dam, T.V.A., 27 Circle Hill Drive, Knoxville, Tenn. 1942
DAVIS, DAVID E., Assistant Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. 1925
DAVIS, GEO. JACOB, JR., Dean and Professor of Civil Engineering, University of Alabama, University, Ala. 1913
DAVIS, HARMER E., Associate Professor of Civil Engineering, University of California, Berkeley, Calif. 1933
DAVIS, HARVEY N., President, Stevens Institute of Technology, Hoboken, N. J. (*Member of Council, 1934–7.*) 1929
DAVIS, HOWARD L., Vocational Director, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. **In military service** 1929
DAVIS, HUGH J., Instructor in Civil Engineering, Southern Methodist University, Dallas, Texas 1940
DAVIS, LOUIS E., Assistant Professor of Mechanical Engineering, Georgia School of Technology, Atlanta, Ga. 1942
DAVIS, RAYMOND E., Professor of Civil Engineering, Director, Engineering Materials Laboratory, University of California, Berkeley, Calif. 1913
DAVIS, ROLAND P., Dean, College of Engineering, West Virginia University, Morgantown, W. Va. 1932
DAVIS, STEPHEN S., Instructor in Mechanical Engineering, Howard University, Washington, D. C. 1941
DAVIS, WATSON M., Assistant Professor of Mechanical Engineering, Cornell College, Mount Vernon, Iowa 1939
DAVISON, ALBERT W., Scientific Director, Owens-Illinois Fiberglas Corp., Newark, Ohio 1936
DAWES, CHESTER L., Associate Professor of Electrical Engineering, Harvard University, Cambridge, Mass. 1915
DAWES, LYMAN M., Assistant Professor of Industrial Applications, Massachusetts Institute of Technology, Cambridge, Mass. 1926
DAWLEY, E. R., Professor of Engineering Materials, Kansas State College, Manhattan, Kans. 1926

DAWSON, CHARLES H., Instructor in Engineering, University of Rochester, Rochester, N. Y. **In military service** 1939
DAWSON, EUGENE F., Professor and Director, School of Mechanical Engineering, University of Oklahoma, Norman, Okla. 1942
DAWSON, F. M., Dean, College of Engineering, State University of Iowa, Iowa City, Iowa. (*Member of Council, 1941–4.*) 1910
DAWSON, JOHN H., Instructor in Civil Engineering, Lafayette College, Easton, Pa. 1942
DAWSON, RAYMOND F., Associate Professor of Civil Engineering; Testing Engineer and Assistant Director, Bureau of Engineering Research, University of Texas, Austin, Texas 1935
DEAN, GEORGE T., Assistant Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1941
DEARBORN, R. H., Dean, School of Engineering, Director, Engineering Experiment Station, Oregon State College, Corvallis, Ore. 1917
DE BAUFRE, WM. L., Chairman, Department of Engineering Mechanics, University of Nebraska, Lincoln, Nebr. 1920
DECKER, FLOYD A., Associate Professor of Electrical Engineering, Texas College of M. & M., El Paso, Texas 1940
DE GARMO, E. PAUL, Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. 1939
DEGLER, HOWARD E., Professor and Chairman, Dept. of Mechanical Engineering, University of Texas, Austin, Texas. (*Member of Council, 1940–43.*) 1930
DELAUBENFELS, C. R., Instructor in Aeronautical Engineering, Los Angeles City College, Los Angeles, Calif. 1939
DELENK, W. N., Head, Dept. of Tool Engineering, Fenn College, Cleveland, Ohio 1939
DELL, GEORGE H., Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1932
DELLER, ANTHONY W., Lecturer, School of Engineering, Columbia University, 67 Wall St., New York City 1940
DELLER, RUSSEL A., Technical Employment Manager, Bell Telephone Laboratories, 463 West Street, New York, N. Y. 1931
DE MOYER, ROBERT, Assistant Professor of Civil Engineering, Lafayette College, Easton, Pa. 1938
DENIS, BROTHER A., Assistant Professor and Head, Dept. of Engineering Drawing, Manhattan College, New York City 1939
DENNISON, B. C., Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1936
DENT, JOHN A., Professor of Mechanical and Aeronautical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1911
DENT, JOSEPH B., Associate Professor of Engineering Drawing, Virginia Polytechnic Institute, Blacksburg, Va. 1935
DERLETH, CHAS., JR., Professor and Chairman, Dept. of Civil Engineering, University of California, Berkeley, Calif. 1904
DE RONDE, LOUIS A., Assistant Professor of Mathematics, New York University, New York City 1936
DESCHNER, WALTER W., Assistant Professor of Chemical Engineering, University of Kansas, Lawrence, Kansas 1935
DEVINE, JAMES J., Associate Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1930
DEVINE, J. JAMES, Assistant Professor of Engineering Drawing, Northeastern University, Boston, Mass. 1935

DEVOR, ELMER L., Assistant Professor of Administrative Engineering, Syracuse University, Syracuse, N. Y. 1938
DEWITT, C. C., Professor and Chairman of Chemical Engineering and Chemistry, Michigan State College, East Lansing, Mich. 1937
DIAKOFF, ALEXIS J., Professor and Head, Department of Mechanical Engineering, University of North Dakota, Grand Forks, N. D. 1938
DIBERT, HERBERT M., Secretary and Treasurer, W. & L. E. Gurley, Troy, N. Y. 1913
DIEFENDORF, ADELBERT, Professor and Head, Dept. of Civil Engineering, University of Utah, Salt Lake City, Utah 1922
DIETZ, ALBERT G., Assistant Professor of Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass. 1940
DIETZ, J. W., Personnel Relations Manager, Mfg. Dept., Western Electric Co., Inc., 195 Broadway, New York City 1911
DILLINGHAM, HARLEY C., Professor of Electrical Engineering, A. & M. College of Texas, College Station, Texas 1929
DILLMAN, GROVER C., President, Michigan College of Mining and Technology, Houghton, Mich. 1936
DIMICK, CHESTER E., Commander, Professor of Mathematics, U. S. Coast Guard Academy, New London, Conn. 1933
DIRKS, HENRY B., Dean of Engineering, Michigan State College, East Lansing, Mich. (*Member of Council, 1932–35.*) 1920
DISQUE, FREDERICK C., Instructor in Chemistry and Mathematics, Pratt Institute, Brooklyn, N. Y. 1940
DISQUE, ROBERT C., Dean of Engineering, Drexel Institute of Technology, Philadelphia, Pa. (*Member of Council, 1928–31.*) 1927
DISTLER, THEODORE A., President, Franklin and Marshall College, Lancaster, Pa. 1928
DIX, L. E., Professor of Mathematics, Norwich University, Northfield, Vt. 1917
DIXON, DON P., Assistant Professor of Mechanical Drawing, Louisiana State University, University, La. 1935
DIXON, HARRY S., Electrical Test Engineer, Douglas Aircraft Co., El Segundo, Calif. 1938
DIXON, TOD G., Head, Dept. of Chemical Engineering, Pratt Institute, Brooklyn, N. Y. 1932
DOAN, GILBERT E., Professor and Head, Dept. of Metallurgical Engineering, Lehigh University, Bethlehem, Pa. 1936
DOBBS, F. E., Principal, Wentworth Institute, Boston, Mass. 1941
DODD, CHARLES M., Professor and Head, Dept. of Ceramic Engineering, Iowa State College, Ames, Iowa 1937
DODDS, JOHN S., Professor of Civil Engineering, Iowa State College, Ames, Iowa 1928
DODGE, BARNETT F., Professor and Chairman, Dept. of Chemical Engineering, Yale University, New Haven, Conn. 1937
DODGE, ELDON R., Instructor in Civil Engineering, University of Wisconsin, Madison, Wis. 1942
DODGE, H. L., Director, School of Engineering Physics, Dean, Graduate School, University of Oklahoma, Norman, Okla. (*Member of Council, 1942–45.*) 1919
DODGE, JOHN F., Professor and Head, Division of Petroleum Engineering, University of Southern California, Los Angeles, Calif. 1933
DODGE, RUSSELL A., Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. 1938

DOERINGSFELD, HARRY A., Assistant Professor of Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. 1932
DOERR, LAWRENCE O., Assistant Professor of Mechanical Engineering, North Dakota Agricultural College, Fargo, N. D. 1935
DOGGETT, L. A., Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. 1914
DOHERTY, R. E., President, Carnegie Institute of Technology, Pittsburgh Pa. (*Member of Council, 1930–33.*) 1923
DOHRENWEND, CLAYTON O., Research Engineer, Armour Research Foundation, Chicago, Ill. 1935
DOLAN, THOMAS J., Associate Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. **In military service** .. 1936
DOLL, ALFRED W., Head, Dept of Engineering Physics, Pratt Institute, Brooklyn, N. Y. 1926
DOLL, THEODORE, Engineer, Standard Oil Co. (Ind.), Whiting, Ind. (33 E. Exchange Ave., Crete, Ill.) 1936
DOLVE, R. M., Dean, School of Engineering, North Dakota State College, Fargo, N. D. 1926
DOMONOSKE, ARTHUR B., Executive Head, Department of Mechanical Engineering, Stanford University, Stanford University, Calif. (*Member of Council, 1935–8.*) **In military service** 1913
DONNELL, LLOYD H., Associate Professor of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1939
DONNELL, PHILIP S., Dean, Division of Engineering, Oklahoma A. & M. College, Stillwater, Okla. **In military service** 1927
DONOVAN, EDWARD T., Assistant Professor of Mechanical Engineering, University of New Hampshire, Durham, N. H. 1929
DOODY, THOMAS C., Associate Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. 1939
DOOLEY, C. R., Manager, Industrial Relations, Socony-Vacuum Corps., 26 Broadway, New York, N. Y. (*Member of Council, 1929–32.*) 1907
DOOLITTLE, JESSE S., Associate Professor of Mechanical Engineering, Pennsylvania State College, State College, Pa. 1929
DORNBERGER, WERNER W., Assistant Professor of Architecture, Assistant Supervising Architect, University of Texas, Austin, Texas 1938
DORRANS, JAMES M., Associate Professor of Mechanical Practice, Supt. Engineering Shop Labs., University of Wisconsin, Madison, Wis. ... 1927
DOTY, L. DONALD, Associate Professor of Hydraulic Engineering, Cornell University, Ithaca, N. Y. 1930
DOUGHERTY, C. R. GRAFLY, Instructor in Engineering Drawing, Iowa State College, Ames, Iowa 1938
DOUGHERTY, JOHN W., Assistant Engineer, U. S. Eng. Dept., Box 5180 Metro, Los Angeles, Calif. 1940
DOUGHERTY, N. W., Dean of Engineering, University of Tennessee, Knoxville, Tenn. (*Member of Council, 1941–4.*) 1937
DOUGHTIE, VENTON L., Professor of Mechanical Engineering, University of Texas, Austin, Texas 1930
DOUGLAS, EARL C., Director, Vocational Education, Joliet Junior College, Joliet, Ill. 1930
DOUGLASS, IRWIN B., Associate Professor and Acting Head, Dept. of Chemistry, University of Maine, Orono, Me. 1941
DOUGLAS, J. F. H., Associate Professor of Electrical Engineering, Marquette University, Milwaukee, Wis. 1910
DOUGLAS, MALCOLM S., Associate Professor of Civil Engineering, Case School of Applied Science, Cleveland, Ohio 1925

DOUGLASS, RAYMOND D., Professor of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. 1937
DOW, WILLIAM G., Associate Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1929
DOWELL, DAWSON, Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1936
DOWLING, EDWARD J., Instructor in Drawing, University of Detroit, Detroit, Mich. 1942
DOWMAN, W. S., Manager, Salary Personnel Dept., Goodyear Aircraft Corp., Akron, Ohio 1941
DOWNARD, RICHARD W., Instructor in Mechanical Engineering, Texas A. & M. College, College Station, Texas 1932
DOWNING, DONALD G., Assistant Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934
DOWNING, LEWIS K., Dean and Professor of Civil Engineering, Howard University, Washington, D. C. 1929
DOWNING, RODERICK L., Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1926
DOWNS, JAMES B. T., Instructor in Mechanical Engineering, The Rice Institute, Houston, Texas 1939
DOWNS, WILLIAM S., Professor of Railway Hydraulic Engineering, West Virginia University, Morgantown, W. Va. 1939
DOWS, HAROLD W., Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934
DOYLE, FRANK B., Director of Research, Ingersoll-Rand Company, Phillipsburg, N. J. 1925
DRAFFIN, JASPER O., Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1917
DREESE, ERWIN E., Professor and Chairman, Dept. of Electrical Engineering, The Ohio State University, Columbus, Ohio 1929
DRENICK, RUDOLPH F., Instructor in Mathematics, Villanova College, Villanova, Pa. 1940
DREW, THOMAS B., Associate Professor of Chemical Engineering, Columbia University, New York City 1940
DRIER, ROY W., Associate Professor of Metallurgy, Michigan College of M. & T., Houghton, Mich. **In military service** 1938
DRISCOLL, WILLIAM G., Assistant Professor of Physics and Mathematics, Villanova College, Villanova, Pa. 1939
DRUCKER, ARTHUR E., Dean, School of Mines and Geology, Director, Mining Experiment Station, Washington State College, Pullman, Wash. 1922
DRUM, MARTIN L., Professor of Surveying, Bucknell University, Lewisburg, Pa. 1925
DUCKERING, W. E., Professor of Civil Engineering; Dean of the Faculty, University of Alaska, College, Alaska 1917
DUDLEY, A. M., Engineering Representative in Patent Dept., Westinghouse E. & M. Co., East Pittsburgh, Pa. (*Member of Council, 1931–34.*) 1926
DUDLEY, BEVERLY, Managing Editor, Electronics, McGraw-Hill Publishing Co., 235 W. 71 St., New York City 1942
DUDLEY, SAMUEL W., Dean, School of Engineering, Yale University, New Haven, Conn. (*Member of Council, 1936–39.*) 1921
DUDLEY, WINSTON M., Assistant Professor of Applied Mechanics, Case School of Applied Science, Cleveland, Ohio 1934

DUFF, C. M., Professor of Engineering Mechanics, University of Nebraska, Lincoln, Nebr. 1912
DUKE, CHARLES M., Instructor in Civil Engineering, University of California, Berkeley, Calif. 1939
DUMBLE, WILSON R., Assistant Professor of English, The Ohio State University, Columbus, Ohio 1932
DUNCAN, DAVID C., Professor of Physics, The Pennsylvania State College, State College, Pa. 1939
DUNCAN, DONALD S., Assistant Professor of Physics, Pratt Institute, Brooklyn, N. Y. 1938
DUNCAN, SYDNEY F., Associate Professor of Mechanical Engineering, University of Southern California, Los Angeles, Calif. 1937
DUNCOMBE, CHARLES G., Professor and Head, Dept. of Chemical Engineering, University of Detroit, Detroit, Mich. 1936
DUNHAM, CLARENCE W., Assistant Professor of Civil Engineering, Yale University, New Haven, Conn. 1934
DUNHAM, HEBER, Professor of Engineering Drawing and Descriptive Geometry, New York University, New York, N. Y. 1914
DUNKLE, RALPH W., President, Ohio Institute of Technology, Greenville, Ohio 1940
DUNLAP, A. LEE, Associate Professor of Mechanical Engineering, Tulane University, New Orleans, La. 1934
DUNLOP, JOHN A., Assistant Professor of Geodesy and Transportation Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1937
DUNN, CLARK A., Associate Professor of Civil Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1942
DUNN, COLON H., Instructor in Electrical Engineering, University of New Hampshire, Durham, N. H. 1942
DUNSTAN, GILBERT H., Associate Professor of Sanitary Engineering, University of Alabama, University, Ala. 1928
DUPLANTIER, DONALD A., Associate Professor of Structural Engineering, University of Alabama, University, Ala. 1930
DUPRIEST, JOHN R., Professor and Head, Department of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. 1919
DURAND, W. F., Professor Emeritus, Stanford University, Calif. 1899
DUREIN, FRANK M., Professor of Physics, Oklahoma A. & M. College, Stillwater, Okla. 1940
DURLAND, M. A., Professor of Machine Design, Assistant Dean, Kansas State College, Manhattan, Kans. 1926
DURST, ROSS C., Professor of Civil Engineering, University of Akron, Akron, O. 1918
DUSINBERRE, G. M., Assistant Professor of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. **In military service** .. 1939
DUTTON, HENRY P., Professor of Business Mgmt., Dean, Evening Division, Illinois Institute of Technology, Chicago, Ill. 1935
DUVALL, W. CLINTON, Professor and Head, Dept. of Electrical Engineering, University of Colorado, Boulder, Colo. 1919
DWYER, ORRINGTON E., Assistant Professor of Chemical Engineering, University of Rochester, Rochester, N. Y. 1941
DYCHE, H. E., Professor and Head, Dept. of Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914
EAMES, JESSE J., Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1935

EARLE, CHESTER R., Associate Editor, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill. 1922

EARLE, S. B., Dean of Engineering, Director of the Engineering Experiment Station, Clemson Agricultural College, Clemson College, S. C. (*President, 1937–38; Member of Council, 1927–30; 1937–.*) 1912

EARNEST, G. BROOKS, Associate Professor of Surveying, Executive Secretary, College Administration, Case School of Applied Science, Cleveland, Ohio 1940

EASTMAN, AUSTIN V., Professor and Head, Dept. of Electrical Engineering, University of Washington, Seattle, Wash. 1939

EATON, PAUL B., Professor and Head, Department of Mechanical Engineering, Lafayette College, Easton, Pa. 1931

EBAUGH, NEWTON C., Professor and Head of Department of Mechanical Engineering, University of Florida, Gainesville, Fla. 1931

EBAUGH, W. C., Professor of Chemistry, Denison University, Granville, Ohio 1908

EBERHART, HOWARD D., Assistant Professor of Civil Engineering, University of California, Berkeley, Calif. 1940

ECKEL, C. L., Professor and Head, Department of Civil Engineering, University of Colorado, Boulder, Colo. (*Member of Council, 1934–7.*) 1914

ECKFELDT, HOWARD, Professor of Mining Engineering, Lehigh University, Bethlehem, Pa. 1936

ECKHARD, G. F., Dean, College of Engineering, University of Vermont, Burlington, Vt. (*Member of Council, 1937–40*) 1910

ECKHARDT, CARL J., JR., Professor of Mechanical Engineering, Supt. of Utilities, University of Texas, Austin, Texas 1929

ECKLE, JOHN N., Assistant Professor of Engineering Drawing, Yale University, New Haven, Conn. 1928

EDDY, C. L., Professor and Head, Department of Engineering Administration, Case School of Applied Science, Cleveland, O. 1910

EDDY, CORBIN T., Associate Professor of Metallurgy, Head, Dept. of Physical Metallurgy, Michigan College of M. & T., Houghton, Mich. 1937

EDELL, GERARD M., Associate Professor and Acting Head, Dept. of Chemical Engineering, Syracuse University, Syracuse, N. Y. 1936

EDGAR, KENNETH K., Assistant Professor of Industrial Administration, Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H. 1937

EDGAR, ROBERT F., Professor of Theoretical and Applied Mechanics, University of Pittsburgh, Pittsburgh, Pa. 1920

EDGECOMB, REX E., Instructor in Engineering Mechanics, University of Nebraska, Lincoln, Nebr. 1941

EDGECOMBE, ARTHUR C., Head, Department of Engineering, Geneva College, Beaver Falls, Pa. 1937

EDISON, OSKAR E., Associate Professor of Electrical Engineering, University of Nebraska, Lincoln, Nebr. 1922

EDMONSON, NAT, JR., Professor of Mathematics, A. & M. College of Texas, College Station, Texas 1938

EDSON, WILLIAM A., Assistant Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1941

EDWARDS, JOHN C., Instructor in Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. **In military service** 1939

EDWARDS, WILLIAM W., Head, Steam Engineering Department, Wentworth Institute, Boston, Mass. 1929

EGGERS, HENRY C. T., Associate Professor of Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. 1922
EGILSRUD, FRIDTJOF S., Head, Mechanical Engineering Laboratory, Pratt Institute, Brooklyn, N. Y. 1928
EGRY, CHARLES R., Associate Professor of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. 1941
EICHLER, JOHN O., Assistant Professor of Civil Engineering, Syracuse University, Syracuse, N. Y. 1939
ELBIN, GUY H., Bridge Engineer, Franklin Co., 555 Evening St., Worthington, Ohio 1924
ELGIN, JOSEPH C., Professor and Chairman, Dept. of Chemical Engineering, Princeton University, Princeton, N. J. (*Member of Council, 1942–45.*) 1931
ELIZONDO, Y. A., Assistant Professor of Mechanical Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1938
ELL, CARL S., President, Northeastern University, Boston, Mass. (*Member of Council, 1940–43.*) 1917
ELLENWOOD, FRANK O., John Edson Sweet Professor of Engineering, Cornell University, Ithaca, N. Y. 1929
ELLIOTT, BEN G., Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. (*Member of Council, 1931–34.*) 1912
ELLIOTT, D. S., Professor of Physics, Tulane University, New Orleans, La. (*Member of Council, 1938–40*) 1919
ELLIOTT, EDWARD C., President, Purdue University, Lafayette, Ind. 1928
ELLIS, CHARLES A., Professor of Structural Engineering, Purdue University, Lafayette, Ind. 1934
ELLIS, W. T., Professor and Head, Dept. of Power and Fuel Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1910
ELLITHORN, HAROLD E., Instructor in Electrical Engineering, University of Notre Dame, Notre Dame, Ind. 1941
ELROD, STEPHEN B., Assistant Professor of Engineering Drawing, Purdue University, Lafayette, Ind. 1940
ELY, JOHN A., Adjunct Professor of Civil Engineering, Cooper Union, New York City 1914
EMERSON, L. A., Professor of Industrial Education, Cornell University, Ithaca, N. Y. 1929
EMERSON, WALTER D., Professor of Mechanical Engineering, Norwich University, Northfield, Vt. 1920
EMERY, KENNETH G., Kelly Field, Texas. **In military service** 1940
EMMONS, WALTER J., Associate Professor of Highway Engineering, University of Michigan, Ann Arbor, Mich. 1923
EMRICK, PAUL S., Electrical Engineer, Lafayette, Ind. 1914
ENDSLEY, L. E., Lecturer in Mechanical Engineering, University of Pittsburgh, 516 East End Avenue, Pittsburgh, Pa. 1907
ENEY, WILLIAM J., Associate Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. 1938
ENGEL, ERNEST D., Assistant Professor of General Engineering, University of Washington, Seattle, Wash. 1935
ENGER, MELVIN L., Dean, College of Engineering, Director, Engineering Experiment Station, Professor of Mechanics and Hydraulics, University of Illinois, Urbana, Ill. (*Member of Council, 1921–24; Vice President, 1938–39.*) 1907
ENNIS, WILLIAM D., A. C. Humphreys Professor of Economics of Engineering, Stevens Institute of Technology, Hoboken, N. J. 1936

ENSIGN, N. E., Associate Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1915
ENTWISLE, FRANK N., Professor and Head, Dept. of Physics, Newark College of Engineering, Newark, N. J. 1927
EPPELSHEIMER, DANIEL S., Research Professor of Industrial Engineering, Acting Director, Engineering Experiment Station, University of New Hampshire, Durham, N. H. 1940
ERIKSEN, EDWARD L., Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. 1937
ERMENC, JOSEPH J., Assistant Professor of Mechanical Engineering, Thayer School of Engineering, Hanover, N. H. 1941
ERNST, GEORGE C., Senior Engineer, Div. Timber Mechanics, Forest Products Lab., Madison, Wis. 1930
ERNST, ROBERT C., Professor and Head, Dept. of Chemical Engineering, University of Louisville, Louisville, Ky. (*Member of Council, 1939–42.*) 1932
ESHBACH, OVID W., Dean, Northwestern Technological Institute, Evanston, Ill. (*Member of Council, 1936–39.*) 1926
ESSIGMANN, MARTIN W., Instructor in Electrical Engineering, Northeastern University, Boston, Mass. 1941
ESTEP, THOMAS G., Professor and Acting Head, Dept. of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1938
EVANS, F. H., District Supt., U. S. Employment Service, Poughkeepsie, N. Y. 1907
EVANS, H. S., Dean, College of Engineering, Professor of Electrical Engineering, University of Colorado, Boulder, Colo. (*President, 1931–32; Vice President, 1920–1; Member of Council, 1931–.*) 1905
EVANS, SIDLEY O., Assistant Professor of Electrical Engineering, Ohio State University, Columbus, Ohio 1939
EVANS, THOMAS H., Associate Professor of Civil Engineering, University of Virginia, University, Va. **In military service** 1936
EVANS, WESTON S., Professor and Head, Dept. of Civil Engineering, University of Maine, Orono, Me. 1922
EVERETT, ALBERT E., Coördinator of Coöperative Work, Northeastern University, Boston, Mass. 1937
EVERETT, FRANKLIN L., Assistant Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. 1939
EVERETT, HAROLD A., Professor and Head, Dept., Mechanical Engineering, Pennsylvania State College, State College, Pa. 1924
EVERITT, WILLIAM L., Professor of Electrical Engineering, The Ohio State University, Columbus, Ohio. **In military service** 1927
EVINGER, M. I., Professor of Civil Engineering, University of Nebraska, Lincoln, Nebr. 1926
EWING, D. D., Professor and Head, School of Electrical Engineering, Purdue University, Lafayette, Ind. 1910
EYRE, THOMAS T., Professor of Mechanical Engineering, University of Southern California, Los Angeles, Calif. 1909
FABEL, DONALD C., Professor and Head, Dept. of Mechanical Engineering, Fenn College, Cleveland, Ohio. **In military service** 1930
FAIG, JOHN T., President, Ohio Mechanics Institute, Cincinnati, O. (*Vice President, 1918–9.*) 1899
FAIR, GORDON M., Gordon McKay Professor of Sanitary Engineering, Harvard Engineering School, Cambridge, Mass. 1926

FAIRBANKS, HAROLD V., Assistant Professor of Chemical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1940
FAIRBANKS, OSCAR W., Associate Professor of Drawing and Design, Michigan State College, East Lansing, Mich. 1937
FAIRBURN, A. JOHN B., Professor and Head, Dept. of Electrical Engineering, University of Akron, Akron, Ohio 1927
FAIRCHILD, EDWARD L., Assistant Professor of Industrial Engineering, University of New Hampshire, Durham, N. H. 1942
FAIRCLOTH, JAMES M., Associate Professor of Civil Engineering, University of Alabama, University, Ala. 1940
FAIRES, VIRGIL M., Professor of Mechanical Engineering, A. & M. College of Texas, College Station, Texas. (*Member of Council, 1939–42.*) 1925
FAIRFIELD, JOHN G., Professor of Heat Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1922
FAIRMAN, SEIBERT, Professor of Applied Mechanics, Purdue University, Lafayette, Ind. (*Member of Council, 1941–4.*) 1921
FAITH, W. LAWRENCE, Professor and Head, Dept. of Chemical Engineering, University of Iowa, Iowa City, Iowa 1934
FALLS, EUGENE K., Instructor in Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. 1941
FARNHAM, CHARLES S., Associate Professor of Civil Engineering, Yale University, New Haven, Conn. 1908
FARNHAM, GEORGE W., Manager, College Dept., International Textbook Co., Scranton, Pa. In military service 1922
FARNHAM, WALTER E., Professor of Engineering Drawing, Tufts College, Medford, Mass. (*Member of Council, 1930–33.*) 1919
FARRELL, F. D., President, Kansas State College. Manhattan, Kans. 1928
FARRIS, MARSHALL E., Dean of Engineering, Professor of Mechanical Engineering, University of New Mexico, Albuquerque, N. M. 1925
FAUCETT, MAX A., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1935
FAWCETT, CHARLES D., Professor of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. 1935
FEIKER, FREDERICK M., Dean, School of Engineering, George Washington University, Washington, D. C. (*Member of Council, 1937–40.*) 1936
FELGAR, J. H., Dean Emeritus; Professor of Engineering, University of Oklahoma, Norman, Okla. (*Member of Council, 1920–3.*) 1912
FELLOWS, JULIAN R., Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1937
FENTON, CHAUNCEY L., Professor, Dept. of Chemistry and Electricity, United States Military Academy, West Point, N. Y. 1930
FENWICK, HAROLD H., Associate Professor of Engineering Drawing, University of Louisville, Louisville, Ky. 1927
FERGUSON, JOSEPH L., Plant Engineer, Glamorgan Pipe & Foundry Co., Lynchburg, Va. 1938
FERGUSON, O. J., Professor of Electrical Engineering, and Dean, College of Engineering, Director, Engineering Experiment Station, University of Nebraska, Lincoln, Nebr. (*President, 1939–40; Vice President, 1923–4; Member of Council, 1939–.*) 1908
FERGUSON, PHIL M., Professor of Civil Engineering, University of Texas, Austin, Texas 1930
FERNALD, ERNEST M., Professor of Mechanical Engineering, Lafayette College, Easton, Pa. 1927

FERNOW, BERNHARD E., Professor and Head, Dept. of Mechanical Engineering, Clemson College, Clemson College, S. C. 1929
FERRETTI, ALFRED J., Professor of Mechanical Engineering, Northeastern University, Boston, Mass. 1925
FERRIS, DELACY F., Curtiss Wright Co., Caldwell, N. J. 1940
FERRY, ARTHUR L., Branch Manager, The A. Lietz Co., 1965 North Berendo St., Los Angeles, Calif. 1940
FESSENDEN, EDWIN A., Russell Sage Professor and Head of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1912
FETHERSTON, THOMAS C., Manager, Publicity Division, Union Carbide Company, 30 E. 42nd St., New York City 1940
FIEDLER, GEORGE J., Associate Professor of Electrical Engineering, Montana State College, Bozeman, Mont. 1940
FIELD, FLOYD, Dean of Men, Director of Personnel, Georgia School of Technology, Atlanta, Ga. 1919
FIELD, WOOSTER B., Professor of Engineering Drawing, The Ohio State University, Columbus, Ohio 1941
FIFE, SAMUEL T., Professor and Head, Dept. of Electrical Engineering, University of Louisville, Louisville, Ky. 1927
FILIPETTI, GEORGE, Professor of Economics and Business Administration, University of Minnesota, Minneapolis, Minn. 1931
FILLION, STANLEY H., Assistant Professor of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1936
FINCH, F. R., Associate Professor of Mechanism and Engineering Drawing, University of Michigan, Ann Arbor, Mich. 1913
FINCH, JAMES K., Renwick Professor of Civil Engineering, Associate Dean, Columbia University, New York City 1925
FINCH, STANLEY P., Professor of Civil Engineering, University of Texas, Austin, Texas 1935
FINEREN, WILLIAM W., Professor of Mechanical Engineering, University of Florida, Gainesville, Fla. 1935
FINNEGAN, JOSEPH B., Professor of Fire Protection Engineering, Illinois Institute of Technology, Chicago, Ill. (*Member of Council, 1933–36.*) 1926
FISCHER, DON A., Instructor in Electrical Engineering, Washington University, St. Louis, Mo. 1941
FISCHER, FREDERIC P., Assistant Professor of Electrical Engineering, Lehigh University, Bethlehem, Pa. 1939
FISH, F. A., Professor of Electrical Engineering, Iowa State College, Ames, Ia. (*Member of Council, 1923–6.*) 1905
FISHER, DAVID A., Assistant Professor of Mechanical Engineering, Tufts College, Medford, Mass. 1938
FISHER, EDWARD G., Instructor in English, Colorado School of Mines, Golden, Colo. 1940
FISHER, HILBERT A., Professor and Head, Dept. of Mathematics, North Carolina State College, Raleigh, N. C. (*Member of Council, 1939–42.*) 1930
FISHER, JAMES, Dean of the Faculty, Michigan College of Mines and Technology, Houghton, Mich. 1899
FISHER, ROBERT A., Associate Professor of Chemical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. In military service .. 1934
FISHMAN, SOLOMON, Assistant Professor of Electrical Engineering, Newark College of Engineering, Newark, N. J. 1928
FITCH, AUSTIN E., Associate Professor of Architectural Construction, Washington University, St. Louis, Mo. 1941

FITCH, W. CHESTER, Instructor in Engineering Drawing, Iowa State College, Ames, Iowa 1939
FITHIAN, JAMES H., Professor and Head, Dept. of Mathematics, Newark College of Engineering, Newark, N. J. 1934
FITTERER, G. R., Professor and Head, Dept. of Metallurgical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1941
FITTERER, J. C., Professor and Head, Dept. of Mathematics, Colorado School of Mines, Golden, Colo. 1912
FITZGERALD, JOHN A., Instructor in Electrical Engineering, University of Dayton, Dayton, Ohio 1941
FLANDERS, MILTON M., Dean of Faculty, Bliss Electrical School, Takoma Park, Washington, D. C. 1939
FLANDERS, ROGER L., Professor of Civil Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
FLANIGAN, ALAN E., Research Associate, University of California, Berkeley, Calif. 1941
FLATH, EARL H., Dean, School of Engineering, Southern Methodist University, Dallas, Texas 1925
FLEMING, ARTHUR P. M., Manager, Research and Education Depts, Metropolitan-Vickers Electrical Co., Manchester, England 1922
FLETCHER, L. J., Director of Training, Caterpillar Tractor Co., Peoria, Ill. (*Member of Council, 1942–45.*) 1941
FLINNER, ARTHUR O., Assistant Professor of Mechanical Engineering, Kansas State College, Manhattan, Kansas. **In military service** 1931
FLINSCH, HAROLD V., Assistant Professor of Civil Engineering, Bucknell University, Lewisburg, Pa. 1940
FLOYD, COLUMBUS, Instructor in Mechanical Engineering, University of Detroit, Detroit, Mich. 1940
FLYNN, EDMUND C., Professor of Civil Engineering, University of Santa Clara, Santa Clara, Calif. 1935
FOCHT, JOHN A., Professor of Highway Engineering, University of Texas, Austin, Texas 1935
FOCKE, THEODORE M., Dean of Faculty, Kerr Professor of Mathematics, Case School of Applied Science, Cleveland, O. (*Member of Council, 1928–31.*) 1907
FOLK, JOHN T., Associate Professor of Engineering, Louisiana Polytechnic Institute, Ruston, La. 1939
FOLK, SAMUEL B., Professor of Mechanics, The Ohio State University, Columbus, Ohio 1921
FOLTZ, LEROY S., Professor and Head, Dept. of Electrical Engineering, Michigan State College, East Lansing, Mich. 1918
FONTAINE, JAMES, Associate Professor of Civil Engineering, North Carolina State College, Raleigh, N. C. 1937
FOOS, CALDWELL B., Industrial Engineer, Kodak Park Works, Eastman Kodak Co., Rochester, N. Y. **In military service** 1940
FOOTE, FRANCIS S., Professor of Railroad Engineering, University of California, Berkeley, Calif. 1939
FOOTE, JAMES H., Supervising Engineer, Commonwealth & Southern Corp., Jackson, Mich. 1933
FORD, ALBERT D., Professor and Head, Dept. of Mechanical Engineering, University of New Mexico, Albuquerque, N. M. 1942
FORD, LESTER R., Professor and Chairman, Dept. of Mathematics, Illinois Institute of Technology, Chicago, Ill. 1939
FORD, WALTER S., Assistant Professor of Electrical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1936

FORMAN, ALEXANDER H., Professor and Head, Dept. of Electrical Engineering, West Virginia University, Morgantown, W. Va. 1937
FORNES, GASTON G., Assistant Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1937
FORSTALL, WALTON, Instructor in Mechanical Engineering, Lehigh University, Bethlehem, Pa. 1941
FORT, TOMLINSON, Dean of Graduate School, Head, Dept. of Mathematics, Lehigh University, Bethlehem, Pa. 1939
FOSS, MARTIN M., President, McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. 1909
FOSS, RAY J., Instructor in Civil Engineering, University of Louisville, Louisville, Ky. 1942
FOSTER, E. S., Electrical Engineer, Standard Transformer Co., R. F. D. 4, Warren, Ohio 1911
FOUNTAIN, ALVIN M., Associate Professor of English, North Carolina State College, Raleigh, N. C. 1937
FOURAKER, LEROY L., Associate Professor of Electrical Engineering, A. & M. College of Texas, College Station, Tex. 1924
FOURAKER, RAYMOND S., Professor of Electrical Engineering, North Carolina State College, Raleigh, N. C. 1929
FOWLER, RUSSELL W., Associate Professor of Mechanical Engineering, Extension Division, University of Wisconsin, Madison, Wis. 1934
FOX, FREDERICK H., Associate Professor of Civil Engineering, Tulane University of Louisiana, New Orleans, La. 1922
FOX, ROBERT M., Professor of Civil Engineering, University of Southern California, Los Angeles, Calif. 1932
FRAAS, ARTHUR P., Instructor in Aeronautical Engineering, New York University, New York City 1942
FRAIM, PARKE B., Associate Professor of Physics, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1926
FRAME, FLOYD H., Professor of Electrical Engineering, Missouri School of Mines, Rolla, Mo. 1924
FRANCIS, SAMUEL A., Head, Department of Mathematics and Engineering, San Mateo Junior College, San Mateo, Calif. 1935
FRAZIER, FORREST F., Professor of Civil Engineering, Kansas State College, Manhattan, Kans. 1929
FRAZIER, RICHARD H., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1927
FRECHETTE, VAN DERCK, 114 Princeton Avenue, Corning, N. Y. 1941
FREEL, WILFRED I., Assistant Professor of Civil Engineering, Purdue University, Lafayette, Ind. 1928
FREEMAN, E. H., Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1909
FREEMAN, MATHEW L., Professor and Head, Department of Drawing, Mississippi State College, State College, Miss. 1928
FREIRE, V. DA SILVA, Professor of Technique of Materials, Dean, Polytechnic School of State, P. O. Box 18, Sao Paulo, Brazil 1929
FRENCH, ARTHUR W., Professor Emeritus of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1900
FRENCH, ORVAL C., Mechanical Engineer, Radiation Lab., University of California, Berkeley, Calif. 1940
FRENCH, ROBERT W., Professor of Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. 1920

FRENCH, THOS. E., Professor of Engineering Drawing, Emeritus, The Ohio State University, Columbus, O. (*Member of Council, 1916–9; Vice President, 1917–8.*) 1899

FREUD, B. B., Professor and Chairman, Dept. of Chemistry, Illinois Institute of Technology, Chicago, Ill. 1934

FREUND, C. J., Dean, College of Engineering, University of Detroit, Detroit, Mich. (*Member of Council, 1941–4.*) 1932

FRIEDRICH, LAWRENCE M., Associate Professor of Civil Engineering, University of Toledo, Toledo, Ohio 1938

FRIGON, AUGUSTIN, President, Ecole Polytechnique, Montreal, Canada. (*Member of Council, 1930–33.*) 1929

FRIGON, RAYMOND A., Instructor in Applied Mechanics, Ecole Polytechnique, Montreal, Canada 1942

FROCHT, MAX M., Associate Professor of Mechanics, Carnegie Institute of Technology, Pittsburgh, Pa. 1928

FROST, DANIEL C., Assistant Professor in charge of Schedules, Newark College of Engineering, Newark, N. J. 1936

FRY, HOWARD M., Professor of Physics and Electricity, Franklin and Marshall College, Lancaster, Pa. 1925

FRY, HORACE P., Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1914

FRY, THORNTON C., Research Mathematician, Bell Telephone Laboratories, Inc., 463 West Street, New York City 1929

FULLAN, M. T., Professor and Head, Dept. of Machine Design and Mechanical Drawing, Alabama Polytechnic Institute, Auburn, Ala. 1915

FULLER, A. H., Professor of Civil Engineering, The Iowa State College, Ames, Iowa. (*Member of Council, 1914–7.*) 1901

FULLER, C. E., Professor Emeritus, Dean of Army Students, Massachusetts Institute of Technology, Cambridge, Mass. 1907

FULLER, LEONARD F., Professor of Electrical Engineering and Chairman of Dept., University of California, Berkeley, Calif. 1930

FULLERTON, HERBERT P., Assistant Professor of Engineering, University of Buffalo, Buffalo, N. Y. 1942

FURIA, JOHN J., Director, Bureau of Training, Civil Service Commission, New York City 1919

FURMAN, FRANKLIN DER., Dean Emeritus, Stevens Institute of Technology, Hoboken, N. J. 1907

FURNAS, C. C., Research Laboratory, Curtiss-Wright Laboratory, Buffalo, N. Y. 1935

GABA, MEYER G., Professor of Mathematics, University of Nebraska, Lincoln, Nebr. 1940

GAFFNEY, BERNARD J., Chemical Engineer, American-Oak Leather Co., Cincinnati, Ohio 1941

GAFFORD, B. NEWMAN, Associate Professor of Electrical Engineering, University of Texas, Austin, Texas 1938

GAGER, FRANK M., Professor of Engineering and Physics, Boston College, Boston, Mass. 1935

GALBRAITH, RALPH A., Assistant Professor of Electrical Engineering, University of Texas, Austin, Texas 1939

GALL, WILLIAM R., Assistant Professor of Mechanical Engineering, University of Louisville, Louisville, Ky. 1941

GALLALEE, JOHN M., Professor and Head, Dept. of Mechanical Engineering, University of Alabama, University, Ala. 1930

GALLEN, JOHN J., Assistant Professor of Civil Engineering, Villanova College, Villanova, Pa. 1940
GAMBLE, WILLIAM H., Professor and Head, Dept. of Electrical Engineering, South Dakota State College, Brookings, S. D. 1931
GAMET, MERRILL B., Assistant Professor of Civil Engineering, Registrar, Northwestern Technological Institute, Evanston, Ill. 1936
GANONG, WARREN L., Instructor in Industrial Engineering, Northeastern University, Boston, Mass. 1942
GARDNER, HOWARD S., Associate Professor of Chemical Engineering, University of Rochester, Rochester, N. Y. 1938
GARDNER, ROBERT A., Hydraulic Engineer, Bureau of Encroachment, Pa. Dept. of Forests and Waters, Harrisburg, Pa. 1930
GARMAN, WARREN D., Assistant Professor of Mechanical Engineering, Bucknell University, Lewisburg, Pa. 1935
GARNER, CLEMENT L., Captain and Chief, Division of Geodesy, Washington, D. C. 1938
GARRAHAN, CHARLES J., Instructor in Electrical Engineering, Swarthmore College, Swarthmore, Pa. 1941
GARRAN, FRANK W., Professor of Civil Engineering, Dean, Thayer School of Engineering, Dartmouth College, Hanover, N. H. 1925
GARRELTS, JEWELL M., Associate Professor of Civil Engineering, Columbia University, New York City 1935
GARRETT, SEYMOUR S., Professor of Industrial Economics, Cornell University, Ithaca, N. Y. 1922
GATCOMBE, ERNEST K., Instructor in Machine Design, Cornell University, Ithaca, N. Y. 1942
GAUDEFROY, HENRI, Assistant to the Dean, Ecole Polytechnique, Montreal, Canada 1942
GAUDIN, ANTOINE M., Richards Professor of Mineral Dressing, Massachusetts Institute of Technology, Cambridge, Mass. 1941
GAULT, ARTHUR E., Dean and Professor of Mathematics, Bradley Polytechnic Institute, Peoria, Ill. 1939
GAUM, CARL G., Professor of University Extension, Rutgers University, New Brunswick, N. J. 1928
GAUSS, HENRY F., Head, Dept. of Mechanical Engineering, University of Idaho, Moscow, Ida. 1926
GAY, HAROLD J., Professor of Mathematics, Worcester Polytechnic Institute, Worcester, Mass. 1930
GAYLORD, CHARLES N., Assistant Professor of Engineering Mechanics, North Carolina State College, Raleigh, N. C. 1937
GAYLORD, EDWIN H., Associate Professor of Civil Engineering, The Ohio University, Athens, Ohio 1936
GEER, ROGER L., Instructor in Materials Processing, Cornell University, Ithaca, N. Y. 1942
GEHMAN, HARRY M., Professor of Mathematics, University of Buffalo, Buffalo, N. Y. 1941
GEHRIG, ARTHUR G., Assistant Professor of Civil Engineering, Pasadena Junior College, Pasadena, Calif. 1929
GEIGER, JOHN W., Assistant Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1923
GELBART, ABE, Instructor in Mathematics, North Carolina State College, Raleigh, N. C. 1940
GEORGE, VINCENT C., Instructor in Physics, Los Angeles City College, Los Angeles, Calif. 1931

GERARDI, JASPER, Director of Engineering Drawing, University of Detroit, Detroit, Mich. 1929
GERTZ, FRED H., Instructor in English, Pratt Institute, Brooklyn, N. Y. 1939
GETCHELL, EDWARD L., Associate Professor of Mechanical Engineering, University of New Hampshire, Durham, N. H. 1921
GEYER, JOHN C., Associate in Civil Engineering, Johns Hopkins University, Baltimore, Md. 1931
GIANNINI, MARIO C., Assistant Professor of Mechanical Engineering, New York University, New York, N. Y. 1935
GIBBS, RUSSELL E., Professor and Head, Dept. of Mechanical Engineering, Montana State College, Bozeman, Mont. 1931
GIBSON, GEORGE, Assistant Professor of Chemistry, Illinois Institute of Technology, Chicago, Ill. 1942
GIBSON, ROBERT, Instructor, ESMWT, University of Florida, 302 Ray St., Gainesville, Fla. 1940
GIESECKE, F. E., Professor Emeritus, Texas A. & M. College, College Station, Texas. (*Member of Council, 1921–4.*) 1893
GIESY, PAUL M., Professor of Chemical Engineering, Newark College of Engineering, Newark, N. J. 1932
GIFFT, HOWARD M., Assistant Professor of Civil Engineering, Cornell University, Ithaca, N. Y. 1941
GILBERT, WILLIAM W., Associate Professor of Metal Processing, University of Michigan, Ann Arbor, Mich. 1940
GILBRETH, LILLIAN M., Professor of Management, Purdue University; Professor of Personnel Relations, Newark College of Engineering; 388 Essex Ave., Bloomfield, N. J. 1938
GILCHRIST, GIBB, Dean of Engineering, A. & M. College of Texas, College Station, Texas 1937
GILES, RANALD V., Associate Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937
GILKEY, HERBERT J., Professor and Head, Department of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa. (*Member of Council, 1936–39.*) 1922
GILLAN, GERALD K., Instructor in Civil Engineering, University of Missouri, Columbia, Mo. 1941
GILLESPIE, MARSHALL F., Salary Personnel Dept., Goodyear Tire & Rubber Co., Akron, Ohio 1942
GILMOUR, WALTER A., Professor of Coördination, University of Akron, Akron, O. 1922
GILPIN, CHARLES A., Assistant Professor of Mechanical Engineering, University of North Dakota, Grand Forks, N. D. 1941
GINGRICH, R. F., Associate Professor of Engineering Drawing, Kansas State College, Manhattan, Kans. 1932
GIRVIN, HARVEY F., Associate Professor of Applied Mechanics, Purdue University, Lafayette, Ind. 1927
GJESDAHL, MAURICE S., Design Engineer, Landis Tool Co., Waynesboro, Pa. 1938
GLASGOW, ROY S., Professor and Chairman, Dept. of Electrical Engineering, Washington University, St. Louis, Mo. 1939
GLEASON, JAMES G., Instructor in Mechanical Engineering, University of Arkansas, Fayetteville, Ark. 1940
GLEESON, GEORGE W., Professor and Head, Dept. of Chemical Engineering, Oregon State College, Corvallis, Ore. 1939
GLENDINNING, WILLIAM, Assistant Supervisor of Training, Consolidated Edison Co. of N. Y., 4 Irving Place, New York City 1937

GLENN, HOWARD E., Associate Professor of Civil Engineering, Clemson Agricultural College, Clemson, S. C. 1939
GLENN, KARL B., Assistant Professor of Electrical Engineering, North Carolina State College, Raleigh, N. C. 1937
GODDARD, EARL G., Instructor in Electrical Engineering, The Rice Institute, Houston, Texas 1941
GODEKE, HARRY F., Professor and Head, Dept. of Mechanical Engineering, Texas Technological College, Lubbock, Texas 1930
GODFREY, WILLIAM P., Assistant Professor of English, University of Detroit, Detroit, Mich. 1929
GOETZ, BILLY E., Instructor in Economics, Illinois Institute of Technology, Chicago, Ill. 1936
GOFF, JOHN A., Dean, Towne Scientific School, University of Pennsylvania, Philadelphia, Pa. 1938
GOGLIA, MARIO J., Associate in Mechanical Engineering, University of Illinois, Urbana, Ill. 1940
GOLDSMITH, ARTHUR, Assistant in Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. (Ensign, U. S. Naval Reserve.) 1939
GOOD, MERRILL R., Professor and Head, Dept. of Industrial Engineering, Assistant Personnel Officer, Montana State College, Bozeman, Mont. 1933
GOODALE, STEPHEN L., Professor of Metallurgical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1941
GOODHEART, CLARENCE F., Instructor in Electrical Engineering, A. & M. College of Texas, College Station, Texas. **In military service** 1939
GOODHEART, EDMUND J., Professor and Head, Mathematics Dept., North Texas Agricultural College, Arlington, Texas. **In military service** 1937
GOODIER, JAMES N., Professor of Mechanics, Cornell University, Ithaca, N. Y. 1941
GOODRICH, ARTHUR L., Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology, Cambridge, Mass. 1930
GOODRICH, RALPH D., Dean, College of Engineering, University of Wyoming, Laramie, Wyo. 1929
GORHAM, ROBERT C., Associate Professor of Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1925
GORMAN, WM. M., Instructor in Mechanical Engineering, Villanova College, Villanova, Pa. 1940
GOSSARD, MYRON L., 3546E Fincastle Road, Louisville, Ky. 1939
GOTAAS, HAROLD B., Professor of Sanitary Engineering, University of North Carolina, Chapel Hill, N. C. **In military service** 1932
GOUGH, ACHILLES C., Professor of Mechanical Engineering, Director of Division, University of Idaho, Southern Branch, Pocatella, Ida. 1922
GOULD, JAY R., Assistant Professor of English, Rensselaer Polytechnic Institute, Troy, N. Y. 1941
GOVIER, CHARLES E., Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. 1930
GOWDY, ROBERT C., Dean, College of Engineering and Commerce, University of Cincinnati, Cincinnati, Ohio 1942
GOWER, ALBERT H., Assistant Professor of Chemical Engineering, Michigan State College, East Lansing, Mich. 1939
GRAESSER, ROY F., Professor and Head, Dept. of Mathematics, University of Arizona, Tucson, Ariz. 1938
GRAF, SAMUEL H., Professor and Head, Dept. of Mechanical Engineering, Director of Engineering Research, Oregon State College, Corvallis, Ore. 1940

GRAHAM, JAMES H., Dean, College of Engineering, University of Kentucky, Lexington, Ky. 1935
GRAHAM, WALTER W., Assistant Professor of Mathematics, Vanderbilt University, Nashville, Tenn. 1939
GRAM, LEWIS M., Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. 1913
GRAMSTORFF, EMIL A., Professor and Head, Dept. of Civil Engineering, Northeastern University, Boston, Mass. 1926
GRANDI, LOUIS L., Assistant Professor of Electrical Engineering, A. & M. College of Texas, College Station, Texas 1937
GRANDLIENARD, EDWARD T., Professor of Civil Engineering, University of Pennsylvania, Philadelphia, Pa. 1919
GRANGER, ARMOUR T., Professor and Head, Dept. of Civil Engineering, University of Tennessee, Knoxville, Tenn. 1939
GRANT, EUGENE L., Professor of Economics of Engineering, Stanford University, Stanford University, Calif. 1925
GRANT, HIRAM E., Assistant Professor of Drawing, University of Wisconsin, Milwaukee, Wis. 1937
GRANTHAM, GUY E., Professor of Physics, Cornell University, Ithaca, N. Y. 1928
GRASSO, SALVATORE, Tutor in Civil Engineering, College of the City of New York, New York City 1939
GRAVES, HAROLD E., Professor of Chemical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1940
GRAVES, QUINTIN B., Assistant Professor of Civil Engineering, University of Texas, Austin, Texas 1939
GRAY, ELLSWORTH S., Associate Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. 1931
GRAY, GEORGE H., Transmission Engineer, International Tel. & Tel. Corp., New York City 1942
GRAY, HAMILTON, Assistant Professor of Civil Engineering, New York University, New York City 1940
GRAY, HENRY C., Instructor in Machine Design, Rose Polytechnic Institute, Terre Haute, Ind. 1929
GRAY, JOHN C., Professor of Chemistry, U. S. Naval Academy, Annapolis, Md. 1920
GRAY, TRUMAN S., Associate Professor of Engineering Electronics, Massachusetts Institute of Technology, Cambridge, Mass. 1939
GRAY, WILLARD F., Assistant Professor of Electrical Engineering, Texas Technological College, Lubbock, Texas 1938
GREAVES-WALKER, A. F., Professor and Head, Dept. of Ceramic Engineering, North Carolina State College, Raleigh, N. C. 1925
GREEN, BOYNTON M., Professor of Mechanical Engineering, Stanford University, Stanford University, Calif. **In military service** 1925
GREEN, ROY C., Naval Ordnance Lab., Washington Navy Yard, 410 A St., S.E., Washington, D. C. 1940
GREEN, ROY M., President and Manager, Western Laboratories, 921 Q St., Lincoln, Nebr. 1940
GREEN, WILSON P., Associate Professor of Mechanical Engineering, University of Maryland, College Park, Md. 1940
GREENE, ARTHUR M., JR., Dean Emeritus, School of Engineering, Princeton University, Princeton, N. J. *(President, 1919–20; Member of Council, 1906–9; 1914–.)* 1903

GREENE, JOHN W., Professor and Head, Dept. of Chemical Engineering, Kansas State College, Manhattan, Kans. **In military service** 1939
GREENSHIELDS, BRUCE D., Associate Professor of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1926
GREENSTEIN, PHILIP, Assistant Professor of Electrical Engineering, New York University, New York City 1938
GREENWALD, DAKOTA U., Mechanical Engineer, Triumph Explosives, Inc., 160 Elkton Rd., Newark, Del. 1938
GREFFE, C. DALE, Instructor in Engineering Drawing, University of Illinois, Urbana, Ill. 1940
GREGORY, CHARLES A., Head, Dept. of Electrical Engineering, Washington and Jefferson College, Washington, Pa. 1942
GREINER, OTTO A., Associate Professor of Modern Languages, Purdue University, Lafayette, Ind. 1922
GREVE, F. W., Professor of Hydraulic Engineering, Purdue University, Lafayette, Ind. 1912
GRIDER, RICHARD L., Associate Professor of Mining Engineering and Drawing, University of Kansas, Lawrence, Kans. 1922
GRIFFIN, FRED S., Professor of Mechanical Engineering, University of Akron, Akron, O. 1922
GRIFFIN, JOHN R., JR., Engineer, Shell Development Co., Emeryville, Calif. 1939
GRIFFITH, D. M., Professor and Chairman, Dept. of Civil Engineering, Bucknell University, Lewisburg, Pa. 1924
GRIFFITH, RUSSELL T., Instructor in Chemical Engineering, Illinois Institute of Technology, Chicago, Ill. 1942
GRIMISON, EDWIN D., Associate Professor of Mechanical Engineering, The Pennsylvania State College, State College, Pa. 1939
GRINTER, LINTON E., Vice President, Dean, Graduate School, Illinois Institute of Technology, Chicago, Ill. (*Member of Council, 1935–8.*) 1928
GRISET, HENRY E., Instructor in Physics. Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1942
GRONE, EDWIN A., Associate Professor of Engineering Mechanics, University of Nebraska, Lincoln, Nebr. 1938
GROSECLOSE, FRANK F., Professor of Industrial Engineering, Director of Cooperative Plan, North Carolina State College, Raleigh, N. C. **In military service** 1937
GROSS, ERIC T. B., Assistant Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. 1942
GROSSER, CHRISTIAN E., Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1940
GROSSER, WILFRED R., Instructor in Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1941
GROSVENOR, A. W., Associate Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937
GUDEBSKI, HENRY C., Instructor in Metallurgy, University of Detroit, Detroit, Mich. 1942
GUERDAN, GEORGE A., Assistant Professor of Mechanical Engineering, College of the City of New York, New York City 1938
GUERNSEY, ROSCOE, Instructor in Civil Engineering, University of Texas, Austin, Texas 1941
GUILD, LAWRENCE R., Professor and Head, Dept. of Management Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1932
GUNDER, D. F., Associate Professor of Mathematics and Civil Engineering, Colorado State College, Ft. Collins, Colo. 1938

GUS, CHARLES E., Executive Secretary, College of Engineering, Professor of Engineering Mechanics, New York University, New York City .. 1926
GUSE, CLARENCE E., Instructor in Applied Electricity, Los Angeles City College, Los Angeles, Calif. 1933
GUTHRIE, ALBERT N., Professor and Chairman, Dept. of Physics, Rhode Island State College, Kingston, R. I. 1937
GUTHRIE, LEDRU O., Instructor in English, University of Minnesota, Minneapolis, Minn. 1938
GWINN, IRA J., Assistant Professor of Physics and Pre-Engineering, Morningside College, Sioux City, Iowa 1934
HAAS, MATTHIAS E., Dean of Engineering, Professor of Chemical Engineering, University of Dayton, Dayton, Ohio 1935
HACHEMEISTER, CHARLES A., Instructor in Drafting, College of the City of New York, New York City 1940
HADDOX, LOUIS C., 315 Pearl St., Hartford, Conn. 1938
HAENISCH, EDWARD L., Associate Professor of Chemistry and Chemical Engineering, Villanova College, Villanova, Pa. 1937
HAENTJENS, CHARLES H., Instructor in Drawing and Mathematics, Santa Rosa Junior College, Santa Rosa, Calif. 1939
HAERTLEIN, ALBERT, Gordon McKay Professor of Civil Engineering, Harvard University, Cambridge, Mass. 1929
HAGA, LOUIS J., Metallurgist, Kaydon Engineering, Muskegon, Mich. .. 1935
HAGERTY, WM. WALSH, 1022 Forest Ave., Ann Arbor, Mich. 1940
HAINES, D. DON, Assistant Professor of Civil Engineering, University of Kansas, Lawrence, Kansas 1935
HALES, VIRGIL D., Assistant Professor and Head, Dept. of Engineering Drawing, Fenn College, Cleveland, Ohio 1930
HALL, AMY V., Assistant Professor of English, University of Washington, Seattle, Wash. 1925
HALL, CLARENCE A., Research Engineer, Ethyl Corp., 1600 W. 8 Mile Rd., Detroit, Mich. 1939
HALL, PHILIP R., Assistant Professor of Industrial Engineering, The Pennsylvania State College, State College, Pa. 1938
HALL, RUSSELL A., Professor of Civil Engineering, Co-Chairman, Division of Engineering, Union College, Schenectady, N. Y. 1925
HALL, STANLEY G., Assistant Professor of General Engineering Drawing, University of Illinois, Urbana, Ill. 1938
HALL, STANLEY R., Senior Design Engineer, Lockheed Aircraft Corp., Burbank, Calif. 1936
HALL, VORIS B., Associate Professor of Physics, Bucknell University Junior College, 158 So. Washington St., Wilkes Barre, Pa. 1927
HALL, WESLEY B., Professor and Head, Dept. of Electrical Engineering, Rhode Island State College, Kingston, R. I. **In military service** .. 1925
HALL, WILLIAM H., Dean, College of Engineering, Duke University, Durham, N. C. 1927
HALLIDAY, WILLIAM R., Professor of Machine Design, Stevens Institute of Technology, Hoboken, N. J. 1926
HALSEY, HUGH, Instructor in Physics, Cooper Union, New York City 1933
HAM, C. W., Professor of Machine Design, University of Illinois, Urbana, Ill. 1933
HAMILTON, EDW. P., President, John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 1914
HAMILTON, ERWIN H., Associate Professor of Automotive Engineering, New York University, New York City 1938

HAMLIN, EDWIN W., Professor of Electrical Engineering, University of Texas, Austin, Texas 1935

HAMMOND, H. P., Dean, School of Engineering, The Pennsylvania State College, State College, Pa. (*Director of Summer Schools for Engineering Teachers, 1927–33; Associate Director of Investigations, 1923–29; Member of Council, 1927–30, 1936–; Vice President, 1934–35; President, 1936–37.*) 1916

HAMMOND, THOMAS M., Head, Dept. of Engineering and Physics, Schreiner Institute, Kerrville, Texas 1940

HANEY, JILES W., Professor and Chairman, Department of Mechanical Engineering, University of Nebraska, Lincoln, Nebr. 1916

HANEY, PAUL D., Assistant Professor of Sanitary Engineering, University of Kansas, Lawrence, Kans. 1940

HANNUM, JOSHUA E., Assistant Dean of Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1935

HANRAHAN, FRANCIS J., Structural Engineer, National Lumber Mfg. Assoc., 6220 Wagner Lane, Bethesda, Md. 1936

HANSELMAN, GEORGE R., Associate Professor of Administrative Engineering, Cornell University, Ithaca, N. Y. 1938

HANSEN, HOWARD J., Instructor in Experimental Engineering, Tulane University, New Orleans, La. 1941

HANSLICK, ROY S. 1939

HANSON, KARL P., Associate Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn. 1941

HANSON, ROBERT S., Associate Professor of Chemistry, Drexel Institute of Technology, Philadelphia, Pa. 1936

HANSON, THOMAS C., Assistant Professor and Acting Head, Dept. of Civil Engineering, University of Detroit, Detroit, Mich. 1941

HANSTEIN, HENRY B., Instructor in Electrical Engineering, College of the City of New York, New York City 1938

HARDER, OSCAR E., Assistant Director, Battelle Memorial Institute, Columbus, Ohio 1925

HARDGRAVE, JOHN C., Associate Professor of Mechanical Engineering, Supt. of Shops, Texas Technological College, Lubbock, Texas 1930

HARDING, GEORGE H., Assistant Professor of Civil Engineering, University of Louisville, Louisville, Ky. (3722 Wendover, Washington, D. C.) 1930

HARGIS, ANDREW B., Dean, School of Engineering, University of Mississippi, University, Miss. 1937

HARKNESS, DANIEL H., Assistant Professor of Civil Engineering, University of Nebraska, Lincoln, Nebr. 1928

HARLOW, HENRY G., Instructor in Civil Engineering, Union College, Schenectady, N. Y. 1942

HARNESS, GEORGE T., Assistant Professor of Electrical Engineering, Columbia University, New York City 1941

HARPER, A. C., President, Wyomissing Polytechnic Institute, Wyomissing, Pa. 1911

HARPER, E. A., Chief Lubricating Engineer, Texas Company, Mortgage Guarantee Building, Atlanta, Ga. 1935

HARRELSON, JOHN W., Dean of Administration, North Carolina State College, Raleigh, N. C. 1933

HARRINGTON, LOUIS C., Dean, College of Engineering, University of North Dakota, Grand Forks, N. D. 1936

HARRINGTON, ROBERT L., Instructor in Mechanical Engineering, Tufts College, Medford, Mass. 1941

HARRINGTON, RUSSELL P., Professor and Head, Dept. of Aeronautical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. ... 1942
HARRIS, C. L., Professor and Head, Dept. of Architectural Engineering, The Pennsylvania State College, State College, Pa. 1914
HARRIS, CHARLES O., Assistant Professor of Mechanics, Illinois Institute of Technology, Chicago, Ill. 1939
HARRIS, ERNEST C., Instructor in Structural Engineering, Fenn College, Cleveland, Ohio 1942
HARRIS, HARRY E., Chief, Engineering Dept., W.P.B.; 229 Thorme St., Bridgeport, Conn. 1924
HARRISON, ED. M., Coördinator, School of Engineering, Southern Methodist University, Dallas, Texas 1939
HARRISON, THOMAS P., Dean, Emeritus, North Carolina State College, Raleigh, N. C. 1942
HART, SIMEON T., Professor and Head, Dept. of Administrative Engineering, Syracuse University, Syracuse, N. Y. 1941
HARTENBERG, RICHARD S., Assistant Professor of Mechanics, Northwestern Technological Institute, Evanston, Ill. 1930
HARTER, G. A., Professor Emeritus, University of Delaware, Newark, Del. 1905
HARTIG, HENRY E., Professor of Communication Engineering, University of Minnesota, Minneapolis, Minn. 1922
HARTLEY, LODWICK C., Professor and Head, Dept. of English, North Carolina State College, Raleigh, N. C. 1940
HARTMAN, PAUL, Instructor in Civil Engineering, College of the City of New York, New York City. **In military service** 1940
HARTSOOK, ARTHUR J., Professor and Head, Division of Chemical Engineering, Rice Institute, Houston, Texas 1938
HASKINS, ELMER E., Associate Professor of Mathematics, Northeastern University, Boston, Mass. 1932
HASKINS, GEORGE W., Major, Army Air Base, Morrison Field, West Palm Beach, Fla. 1940
HASTINGS, HUDSON B., Professor of Economics, Yale University, New Haven, Conn. 1928
HATCH, WM. ERNEST, Engineering Instructor, School of Engineering Science, Hyannis, Mass. 1939
HATCHER, THOMAS W., Professor of Mathematics, Virginia Polytechnic Institute, Blacksburg, Va. 1935
HATHAWAY, ARTHUR S., Assistant Professor of Surveying and Drawing, Northwestern University, Evanston, Ill. 1934
HATTRUP, HUBERT E., Instructor in Electrical Engineering, University of Idaho, Moscow, Ida. 1941
HAUPT, LEWIS M., Associate Professor of Electrical Engineering, A. & M. College of Texas, College Station, Texas 1937
HAUSMANN, ERICH, Professor of Physics, Dean, Graduate Study, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1926
HAWKES, JOHN B., Associate Professor of Physics, Stevens Institute of Technology, Hoboken, N. J. 1939
HAWKINS, GEORGE A., Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1930
HAWKINS, ROBERT D., Professor of Applied Mechanics, University of Kentucky, Lexington, Ky. 1939
HAWLEY, RANSOM S., Professor and Chairman, Dept. of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1940

HAY, EARL D., Head, Department of Mechanical Engineering, University of Kansas, Lawrence, Kans. 1915
HAYES, LESLIE D., Professor and Head, Dept. of Mechanical Engineering, West Virginia University, Morgantown, W. Va. 1935
HAYES, ST. CLAIR J., Associate Professor of Education, Memorial University College, St. Johns, Newfoundland 1935
HAYNES, HAROLD A., Principal, Armstrong Technical High School, Washington, D. C. 1942
HAYNES, HILLIARD G., Assistant Professor of Civil Engineering, The Citadel, Charleston, S. C. 1936
HAYS, FRANK B., M. I. T., Cambridge, Mass. **In military service** 1939
HAYWARD, HAROLD N., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1936
HAZELTINE, ALAN, Professor of Physics, Stevens Institute of Technology, Hoboken, N. J. 1910
HAZEN, HAROLD L., Professor and Head, Dept. of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1938
HAZEN, JOHN W., Instructor in Engineering, Los Angeles City College, Los Angeles, Calif. 1932
HAZEN, LESLIE E., Professor and Head, Dept. of Agricultural Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
HEACOCK, FRANK A., Head, Dept. of Graphics and Engineering Drawing, Princeton University, Princeton, N. J. 1926
HEALD, HENRY T., President, Illinois Institute of Technology, Chicago, Ill. *(President, 1942–43; Vice President, 1941–2; Member of Council, 1938–.)* 1931
HEANY, ARTHUR G., Manager, Text-Book Dept., D. Van Nostrand Company, 250 4th Avenue, New York, N. Y. 1929
HEARD, M. EARL, Dean, Philadelphia Textile School, Philadelphia, Pa. .. 1935
HEATH, CHARLES O., Instructor in Mechanical Engineering, Rutgers University, New Brunswick, N. J. 1942
HEATH, EDWARD B., Associate Professor, San Bernardino Valley Junior College, San Bernardino, Calif. **In military service** 1935
HEBARD, WILLIAM J., Director of Industrial Relations, Marquette University, Milwaukee, Wis. 1936
HEBRANK, EUGENE F., Instructor in Mechanical Engineering, University of Maryland, College Park, Md. 1940
HEDENBERG, NORMAN A., Instructor in Mathematics, Wilbur Wright Junior College, 3400 No. Austin Ave., Chicago, Ill. 1939
HEFFNER, ROY J., Assistant Personnel Director, Bell Telephone Laboratories, 463 West Street, New York, N. Y. 1930
HEIN, JAMES M., Assistant Professor and Head, Dept. of Engineering Drawing, University of North Dakota, Grand Forks, N. D. 1940
HELANDER, LINN, Professor and Head, Department of Mechanical Engineering, Kansas State College, Manhattan, Kansas 1935
HEM, LAWRENCE W., Instructor in Mechanical Engineering, College of the City of New York, New York City. **In military service** 1939
HEMPSTEAD, JEAN C., Associate Professor of General Engineering, Iowa State College, Ames, Iowa. **In military service** 1935
HENDERSON, D. E., Instructor in Industrial Engineering, North Carolina State College, Raleigh, N. C. 1941
HENDERSON, FREDERICK R., Acting Head, Dept. of Industrial Engineering, Assistant Dean, Northeastern University, Boston, Mass. 1940

HENDERSON, JAMES M., Director, Department of Industrial Arts, Professor of Civil Engineering, Tennessee Polytechnic Institute, Cookeville, Tenn. 1930
HENDERSON, ROBERT B. 1939
HENDRICK, T. K. A., Civil Engineer, Board of Water Supply, City of New York, 120 Wall St., New York, N. Y. 1921
HENDRICKS, WALTER, Professor and Head, Department of English and Modern Language, Illinois Institute of Technology, Chicago, Ill. 1933
HENIKA, JOHN H., Foreman, Wood Laboratory, Georgia School of Technology, Atlanta, Ga. 1936
HENLINE, HENRY H., National Secretary, American Institute of Electrical Engineers, 33 W. 39th Street, New York City 1919
HENNES, ROBERT G., Associate Professor of Civil Engineering, University of Washington, Seattle, Wash. 1935
HENNEY, KEITH, Editor, Electronics, McGraw-Hill Publishing Co., 330 W. 42nd St., New York City, ... 1942
HENNINGER, G. ROSS, Editor, American Institute of Electrical Engineers, 33 West 39th St., New York City. **In military service** 1940
HENRY, GEORGE F., Associate Professor of Mechanical Engineering, Colorado State College, Ft. Collins, Colo. 1939
HENRY, HERMAN L., Instructor in Technical Drawing, Illinois Institute of Technology, Chicago, Ill. 1942
HENRY, HOWARD J., Instructor in Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1939
HENRY, JOHN A., Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill. 1941
HENRY, MAXWELL, Assistant Professor of Electrical Engineering, College of the City of New York, New York City 1939
HENSHAW, CHARLES N., Engineer, Pal Blade Co., Plattsburg, N. Y. 1930
HERNDON, LYLE K., Assistant Professor of Chemical Engineering, The Ohio State University, Columbus, Ohio 1938
HERREMAN, HAROLD M., Assistant Professor of Physics, Fresno State College, Fresno, Calif. 1940
HERRICK, CARL A., Associate Professor of Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. 1922
HERRICK, THOMAS J., Assistant Analyst, McDonnell Aircraft Corp., 307 Hillside Ave., Webster Groves, Mo. 1936
HERSEY, MAYO D., Research Associate in Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1936
HERTEL, KENNETH L., Professor and Head, Dept. of Physics, University of Tennessee, Knoxville, Tenn. 1941
HERTZLER, ELMER A., In Charge of Electrical Engineering Laboratory, Pratt Institute, Brooklyn, N. Y. 1929
HESS, HOWARD M., Assistant Professor of Electrical Engineering, Wayne University, Detroit, Mich. 1942
HESS, WENDELL F., Associate Professor and Head of Welding Laboratory, Dept. of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1936
HESSE, HERMAN C., Associate Professor of Engineering Drawing, University of Virginia, University, Va. 1929
HESSLER, VICTOR P., Professor and Chairman, Dept. of Electrical Engineering, University of Kansas, Lawrence, Kansas 1928
HETT, JOHN H., Assistant Professor of Physics, Manhattan College, New York City 1939

HETZEL, THEODORE B., Assistant Professor of Mechanical Engineering, Haverford College, Haverford, Pa. 1936
HEWITT, CECIL M., Professor and Head, Dept. of Automobile and Aeronautics, Bradley Polytechnic Institute, Peoria, Ill. 1942
HIBSHMAN, NELSON S., Professor and Head, Dept. of Electrical Engineering, New York University, New York City 1930
HICKS, WILLIAM N., Professor and Head, Dept. of Ethics and Religion, North Carolina State College, Raleigh, N. C. 1939
HIGBEE, F. G., Professor and Head, Dept., Engineering Drawing, State University of Iowa, Iowa City, Ia. (*Vice President, 1922–3; Member of Council, 1916–9.*) 1906
HIGBIE, H. H., Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. (*Member of Council, 1929–32.*) 1908
HIGDON, R. ARCHIE, Assistant Professor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa. **In military service** 1938
HIGGINS, GEORGE J., Professor and Acting Director of Aeronautical Engineering, University of Detroit, Detroit, Mich. **In military service** 1935
HIGGINS, PAUL R., Assistant Professor of Aeronautical Engineering, A. & M. College of Texas, College Station, Texas 1938
HIGGINS, THOMAS J., Associate Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1940
HILBERRY, H. NORMAN, Assistant Professor of Physics, New York University, New York City 1935
HILL, ARTHUR M., Associate Professor of Heat Engineering, Tulane University, New Orleans, La. 1931
HILL, A. S., Professor of Electrical Engineering, University of Maine, Orono, Me. 1919
HILL, FRANCIS M., Instructor in Engineering Drawing and Mechanics, George School of Technology, Atlanta, Ga. 1936
HILL, IVAN L., Assistant Professor of Technical Drawing, Illinois Institute of Technology, Chicago, Ill. 1942
HILL, J. LAWRENCE, JR., Assistant Professor of Mechanical Engineering, University of Rochester, Rochester, N. Y. 1936
HILLYARD, LAWRENCE R., Assistant Professor of General Engineering, Iowa State College, Ames, Iowa 1940
HINCKLEY, A. DEXTER, Assistant to the Dean, Instructor in Electrical Engineering, Columbia University, New York City 1929
HINKLE, ROLLAND T., Instructor in Machine Design, Cornell University, Ithaca, N. Y. 1942
HINMAN, JACK, JR., Associate Professor of Sanitation, State University of Iowa, Iowa City, Iowa. **In military service** 1936
HINTON, WILLIAM A., Assistant Professor of Mechanical Engineering, Duke University, Durham, N. C. 1935
HITCHCOCK, E. A., Dean Emeritus, The Ohio State University, Columbus, O. (*Vice President, 1929–30; Member of Council, 1922–5.*) 1921
HITCHCOCK, LEON W., Professor of Electrical Engineering, Acting Dean, University of New Hampshire, Durham, N. H. 1922
HITCHCOCK, WARREN W., Assistant Professor of Civil Engineering, Michigan State College, East Lansing, Mich. 1937
HIXON, CHARLES R., Professor and Head, Dept. of Mechanical Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1910
HIXSON, ARTHUR W., Executive Officer, Dept. of Chemical Engineering, Columbia University, New York City 1937

HOAD, W. C., Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. (*Member of Council, 1925–8.*) 1907
HOADLEY, ANTHONY, Acting Professor and Chairman, Dept. of Civil Engineering, Union College, Schenectady, N. Y. 1928
HOADLEY, GEORGE B., Assistant Professor of Graduate Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1935
HOBSON, JESSE E., Professor and Director, Dept. of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1942
HOCKEMA, FRANK C., Assistant to the President, Professor of Industrial Engineering, Purdue University, Lafayette, Ind. 1921
HODGE, CHARLES A., Head Instructor in Electrical Engineering, Yonkers Technical High School, Yonkers, N. Y. 1932
HODGE, WILLARD W., Professor and Head, Dept. of Chemical Engineering, Assistant Director, Engineering Experiment Station, West Virginia University, Morgantown, W. Va. 1930
HODGINS, LAWRENCE J., Associate Professor of Electrical Engineering, University of Maryland, College Park, Md. 1939
HOEFER, E. G., Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1910
HOELSCHER, RANDOLPH P., Professor of General Engineering Drawing, University of Illinois, Urbana, Ill. (*Member of Council, 1911–4.*) 1912
HOFFMAN, OSCAR, Associate Professor of Structural Engineering, Fenn College, Cleveland, Ohio 1941
HOFFMAN, P. C., Instructor in Engineering Drawing, University of Detroit, Detroit, Mich. 1939
HOFMANN, G. A., Professor and Head, Dept. of Mechanical Engineering, University of Dayton, Dayton, O. 1916
HOLBROOK, E. A., Dean, Schools of Engineering and Mines, University of Pittsburgh, Pittsburgh, Pa. (*Member of Council, 1936–39.*) 1927
HOLCOMB, ROBERT M., Designer, Donald R. Warren, Los Angeles; 1651 Palmyrita, Riverside, Calif. 1938
HOLLAND, A. DINSMORE, Associate Professor of Mechanical Engineering, Georgia School of Technology, Atlanta, Ga. 1933
HOLLAND, LEWIS N., Assistant Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1940
HOLLAND, UBERT C., Professor of Engineering Drawing, Assistant to Dean, Rutgers University, New Brunswick, N. J. 1930
HOLLISTER, S. C., Dean, College of Engineering, Cornell University, Ithaca, N. Y. (*Member of Council, 1937–40*) 1916
HOLLISTER, VERNON L., Professor of Electrical Engineering, University of Nebraska, Lincoln, Nebr. 1940
HOLMAN, LEON W., Instructor in Architectural Engineering, Los Angeles City College, Los Angeles, Calif. 1936
HOLMBERG, CARL H., Assistant Professor of Civil Engineering, Tufts College, Medford, Mass. 1924
HOLME, JUSTUS M., Instructor in Mechanics, The Pennsylvania State College, State College, Pa. 1938
HOLME, THOMAS T., Instructor in Mechanical and Industrial Engineering, Lehigh University, Bethlehem, Pa. 1940
HOLMES, CLAYTON W., Associate Professor of Mechanical Engineering, Haverford College, Haverford, Pa. 1933
HOLMES, FRED E., Assistant Professor of Mechanics and Hydraulics, The State University of Iowa, Iowa City, Ia. 1919

HOLMES, LYNN C., Assistant Professor of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1937
HOLMES, MAJOR E., Dean, New York State College of Ceramics at Alfred University, Alfred, N. Y. 1937
HOLMES, WILFRED J., Assistant Professor of Engineering, University of Hawaii, Honolulu, T. H. **In military service** 1937
HOLT, A. H., Professor and Head, Dept. of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. **In military service** 1923
HOLT, CLIFFORD B., JR., Assistant Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. 1933
HOLTBY, FULTON, Assistant Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. 1941
HONOUR, WILFRED M., Assistant Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1941
HOOD, ARTHUR A., Director of Dealer Relations, Johns-Manville Sales Corp., 22 E. 40th St., New York City 1942
HOOD, GEO. J., Professor of Engineering Drawing, University of Kansas, Lawrence, Kans. 1914
HOOKE, ROBERT, Instructor in Mathematics, North Carolina State College, Raleigh, N. C. 1941
HOOPER, WM. T., Structural Designer, Greeley & Hansen, Chicago, Ill. .. 1940
HOOVER, P. L., Professor and Head, Dept. Electrical Engineering, Case School of Applied Science, Cleveland, Ohio 1931
HOPPER, JOHN S., Assistant Professor of Mechanical Engineering, A. & M. College of Texas, College Station, Texas 1937
HORACK, CARL W., Assistant Chief Engineer, Merco-Nordstrom Valve Co., 1155 Colusa Ave., Berkeley, Calif. 1933
HORAN, FRANK W., Professor of Civil Engineering, University of Notre Dame, Notre Dame, Ind. 1938
HORN, CLIFFORD R., Assistant Professor of Petroleum Engineering, Texas Technological College, Lubbock, Texas 1941
HORN, HARRY W., Instructor in Electrical Engineering, University of Illinois, Urbana, Ill. 1938
HORTON, PAUL M., Professor and Head, Dept. of Chemical Engineering, Louisiana State University, University, La. 1931
HOSTETTER, HARRY C., Instructor in Mathematics and Physics, Pratt Institute, Brooklyn, N. Y. 1926
HOTCHKISS, CHARLES H. B., Editor, *Heating and Ventilating*, 148 Lafayette St., New York City 1925
HOTCHKISS, W. E., Maurice Falk Professor of Social Relations, Carnegie Institute of Technology, Pittsburgh, Pa. 1939
HOTCHKISS, W. O., President, Rensselaer Polytechnic Institute, Troy, N. Y. 1926
HOTTLE, WARREN M., Instructor in Physics, Pratt Institute, Brooklyn, N. Y. 1938
HOUCHENS, JOHN M., Coördinator, University of Louisville, Louisville, Ky. 1930
HOUGEN, OLAF A., Professor of Chemical Engineering, University of Wisconsin, Madison, Wis. 1930
HOUK, HOWARD H., Lt. Comdr., C. E. C., U. S. N. R., 2562 36th St., N.W., Washington, D. C. 1938
HOUSEL, WILLIAM S., Associate Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. **In military service** 1938
HOUSER, SHALER C., Professor of Engineering, University of Alabama, University, Ala. 1934

HOUSTON, HARRY H., Associate Professor of Chemical Engineering, University of Florida, Gainesville, Fla. 1938
HOVEY, B. K., Instructor in Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1939
HOWARD, DARNLEY E., Associate Professor of Mechanical Engineering, Howard University, Washington, D. C. 1928
HOWARD, JOHN W., Associate Professor of Topographical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1907
HOWE, EVERETT D., Associate Professor of Mechanical Engineering, University of California, Berkeley, Calif. 1931
HOWE, JEROME W., Dean of Students and Admissions, Worcester Polytechnic Institute, Worcester, Mass. 1925
HOWE, JOSEPH W., Professor and Head, Dept. of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa 1934
HOWE, LEON B., Professor of Technical Drawing, College of Applied Science, Syracuse University, Syracuse, N. Y. 1917
HOWELL, ALVIN H., Chairman, Dept. of Electrical Engineering, Tufts College, Medford, Mass. 1941
HOWELL, E. J., Registrar, A. & M. College of Texas, College Station, Texas. **In military service** 1937
HOWELL, ERIC V., Assistant Professor of Mechanics, Cornell University, Ithaca, N. Y. 1927
HOWELL, ROGER S., Professor of Mechanical Engineering, Director of Evening School, Georgia School of Technology, Atlanta, Ga. 1919
HOWES, DOUGLAS E., Professor of Electrical Engineering, Norwich University, Northfield, Vt. 1935
HOWLAND, WARREN E., Professor of Sanitary Engineering, Purdue University, Lafayette, Ind. 1926
HOWSON, ELMER T., Vice President and Western Editor, *Railway Age*, 105 West Adams St., Chicago, Ill. 1939
HOY, ELVIN A., Associate Econ. Statistician, War Production Board, 5534 Empire State Bldg., New York City 1930
HOYT, CRAIG S., Head, Chemistry, Grove City College, Grove City, Pa. .. 1942
HUBLER, JOHN W., Assistant Professor of Civil Engineering, Washington University, St. Louis, Mo. 1939
HUCKERT, JESSE W., Associate Professor of Mechanical Engineering, University of Maryland, College Park, Md. **In military service** .. 1938
HUCKLE, MYRON S., President, U. S. Diesel Engineering School, 89–91 Brighton Ave., Boston, Mass. **In military service** 1937
HUDSON, PAUL K., Instructor in Electrical Engineering, University of Idaho, Moscow, Idaho 1942
HUDSON, ROSS C., Associate Professor of Civil Engineering, Clarkson College of Technology, Potsdam, N. Y. 1940
HUFFMAN, HAROLD F., Professor and Head, Dept. of Electrical Engineering, Southern Methodist University, Dallas, Texas 1937
HUFFMAN, JOHN R., Field Engineer, Columbia War Research Division, New York City 1938
HUGHES, FORREST R., Assistant Professor of Engineering Drawing, Yale University, New Haven, Conn. 1935
HUGHES, GEORGE G., Dean, College of Engineering, Southwestern Louisiana Institute, Lafayette, La. 1924
HUGHES, MARTIN C., Professor and Head, Dept. of Electrical Engineering, A. & M. College of Texas, College Station, Texas 1932

HUGO, MERRILL S., Assistant Professor of Mechanical Engineering, Stanford University, Stanford University, Calif. **In military service** .. 1941
HULL, ROBERT H., Associate Professor of Electrical Engineering, University of Utah, Salt Lake City, Utah 1929
HULL, WILLIAM L., Assistant Professor of Mechanical Engineering, University of Colorado, Boulder, Colo. 1940
HUME, ALFRED, Acting Chancellor, Head, Mathematics Dept., University of Mississippi, University, Miss. 1894
HUME, WILLIAM, Assistant Professor of Civil Engineering, University of New Mexico, Albuquerque, N. M. 1936
HUMMEL, JESSE G., Associate Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1940
HUMMEL, JOSEPH O. P., Associate Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. 1933
HUMPHREY, ELMER N., Instructor in Agricultural Engineering, University of Idaho, Moscow, Ida. 1940
HUNT, DEWITT, Professor and Head, Department of Industrial Arts Education and Engineering Shopwork, Oklahoma A. & M. College, Stillwater, Okla. 1931
HUNT, GUY H., Assistant Professor of Applied Mathematics, University of California at Los Angeles, Calif. 1923
HUNT, LOUIS W., Professor of Chemical Engineering, Fenn College, Cleveland, Ohio 1930
HUNT, MELVIN W., Mechanical Engineer, Dow Styrene Plant, 815 McDonald St., Midland, Mich. 1918
HUNT, ORVILLE D., Associate Professor of Electrical Engineering, Kansas State College, Manhattan, Kans. 1927
HUNTER, MATTHEW A., Professor and Head, Dept. of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1938
HUNTINGTON, W. C., Professor and Head, Dept. of Civil Engineering, University of Illinois, Urbana, Ill. (*Member of Council, 1929–32.*) 1914
HUNTLEY, PHIL C., Professor and Director of Civil Option, Illinois Institute of Technology, Chicago, Ill. 1938
HURTUBISE, JACQUES E., Assistant Professor of Civil Engineering, Ecole Polytechnique, Montreal, Canada 1942
HUSSEY, ROBERT A., Associate Professor of Industrial Engineering, The Pennsylvania State College, State College, Pa. 1937
HUTCHINS, ROLAND E., Associate Professor of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1936
HUTCHINSON, CHARLES A., Professor and Head, Dept. of Engineernig Mathematics, University of Colorado, Boulder, Colo. 1923
HUTCHISON, ALBERT W., JR., Associate Professor of Civil Engineering, Vanderbilt University, Nashville, Tenn. 1934
HYDE, CHARLES G., Professor of Sanitary Engineering, University of California, Berkeley, Calif. 1940
HYDE, THOMAS E., Instructor in Engineering, North Carolina State College, Raleigh, N. C. 1941
HYDE, WILLIAM H., Librarian, College of Engineering, Cornell University, Ithaca, N. Y. 1942
HYDEMAN, WILLIAM R., Instructor in Mathematics, U. S. Naval Academy, Annapolis, Md. 1941
HYSLOP, WILLIAM H., Professor of Physics, University of Denver, Denver, Colo. 1941
INGALLS, JAMES W., Associate Professor of Industrial Research, Norwich University, Northfield, Vt. 1940

INGERSOLL, LEONARD R., Professor and Chairman, Dept. of Physics, University of Wisconsin, Madison, Wis. 1941
IRESON, WILLIAM G., Assistant Professor of Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1941
IRLAND, GEORGE A., Professor of Electrical Engineering and Chairman of Engineering, Bucknell University, Lewisburg, Pa. 1927
IVES, HOWARD C., Civil and Consulting Engineer, P. O. Box O, San Clemente, Calif. 1933
JACKLIN, H. M., Professor of Automotive Engineering, Purdue University, Lafayette, Ind. 1937
JACKSON, DUGALD C., Professor Emeritus, Massachusetts Institute of Technology, 5 Mercer Circle, Cambridge, Mass. (*President, 1906–7; Member of Council since 1906; Member, Board of Investigation and Coördination, 1922–33.*) **Fourth Recipient Lamme Medal (1931).** 1893
JACKSON, DUGALD, JR., Dean, College of Engineering, University of Notre Dame, Notre Dame, Ind. **In military service** 1922
JACKSON, FREDERICK D., Associate Professor of Electrical Engineering, University of New Hampshire, Durham, N. H. 1935
JACOBUS, D. S., Retired, 93 Harrison St., Montclair, N. J. 1893
JACOBY, HENRY S., Professor of Bridge Engineering, Emeritus, Cornell University, 3000 Tilden St., N.W., Washington, D. C. (*President, 1915–6; Vice President, 1913–4; Secretary, 1900–2; Member of Council, 1900–5; 1915–.*) 1894
JAGGER, JAMES E., Acting Assistant Secretary, American Society of Civil Engineers, 33 W. 39th St., New York City 1942
JAKKULA, A. A., Professor of Structural Engineering, A. & M. College of Texas, College Station, Texas 1938
JAKOB, MAX, Research Professor of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1941
JAKOWSKY, JOHN J., Dean, Schools of Engineering and Architecture, University of Kansas, Lawrence, Kansas 1942
JAMES, RICHARD V., Professor of Mechanics, Director of General Engineering, University of Oklahoma, Norman, Okla. 1937
JAMIESON, ROBERT E., William Scott Professor and Chairman, Dept. of Civil Engineering, McGill University, Montreal, Canada 1929
JANES, CLINTON W., Liaison Officer to Chief Signal Officer, Mass. Inst. Tech., Cambridge, Mass. **In military service** 1938
JANSKY, CYRIL M., Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1924
JANSSEN, ALLEN S., Assistant Professor and Testing Engineer, in Civil Engineering, University of Idaho, Moscow, Idaho. **In military service** 1931
JAPPE, KURT W., Director of Purchases, Hercules Powder Co., Wilmington, Del. 1936
JENKINS, DAVID R., Professor and Head, Dept. of Electrical Engineering, University of North Dakota, University Station, Grand Forks, N. D. 1912
JENKINS, HOWARD M., Associate Professor of Electrical Engineering, Swarthmore College, Swarthmore, Pa. 1931
JENNINGS, BURGESS H., Professor and Chairman, Dept. of Mechanical Engineering, Northwestern Technological Institute, Evanston, Ill. .. 1933
JENNINGS, ROY T., Assistant Professor of Civil Engineering, North Dakota Agricultural College, Fargo, N. D. 1939
JENSEN, ALFRED, Assistant Professor of General Engineering, University of Washington, Seattle, Wash. 1932

Jensen, Cyril D., Associate Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. **In military service** 1936
Jensen, Gordon L., Field Supervisor, Bureau of Unemployment Compensation, Columbus, Ohio 1929
Jessup, Walter E., Acting Assistant Secretary, American Society of Civil Engineers, 33 W. 39th Street, New York City 1937
Jett, Carter C., Professor of Machine Design, University of Kentucky, Lexington, Ky. 1925
Jewell, William R., Instructor in Drawing and Machine Design, University of Colorado, Boulder, Colo. 1941
Jewett, F. B., Vice President, American T. & T. Co., Chairman, Board of Directors, Bell Telephone Laboratories, Inc., 195 Broadway, New York, N. Y. 1914
Joerger, C. Albert, Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio 1929
Joffe, Joseph, Professor of Chemical Engineering, Newark College of Engineering, Newark, N. J. 1937
Johns, William B., Jr., Professor and Head, Dept. Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. 1935
Johnson, Albert P., Assistant Director of Personnel, Purdue University, Lafayette, Ind. **In military service** 1941
Johnson, A. R., Professor of Structural Design, Rutgers University, New Brunswick, N. J. 1909
Johnson, Bertram C., Instructor in Engineering Drawing, Iowa State College, Ames, Iowa 1914
Johnson, C. David, Assistant Professor of Physics, Northeastern University, Boston, Mass. 1940
Johnson, Elmer W., Associate Professor of Electrical Power Engineering, University of Minnesota, Minneapolis, Minn. 1926
Johnson, Franklin C., Remington Arms Co., Bridgeport, Conn. 1939
Johnson, F. Ellis, Dean, College of Engineering, University of Wisconsin, Madison, Wis. (*Member of Council, 1932–35.*) 1916
Johnson, J. Hugo, Professor and Head, Department of Electrical Engineering, Acting Dean, University of Idaho, Moscow, Ida. 1926
Johnson, Lee H., Dean, Professor of Civil Engineering, University of Mississippi, University, Miss. 1937
Johnson, Lewis O., Instructor in Engineering Drawing, New York University, New York City 1939
Johnson, Maurice F., Professor of Engineering, Hillyer Junior College, Hartford, Conn. 1936
Johnson, Ralph R., Industrial Coördinator, University of Detroit, Detroit, Mich. 1941
Johnson, Walter A., Instructor in Machine Design, Cornell University, Ithaca, N. Y. 1941
Johnson, William C., Jr., Director of Placement, Associate Professor of Vocational Guidance, Virginia Polytechnic Institute, Blacksburg, Va. 1935
Johnston, Bruce, Assistant Professor of Civil Engineering, Assistant Director, Fritz Engineering Lab., Lehigh University, Bethlehem, Pa. **In military service** 1935
Johnstone, B. Kenneth, Professor and Head, Dept. of Architecture, The Pennsylvania State College, State College, Pa. 1938
Jonassen, Finn, Instructor in Mechanical Engineering, University of California, Berkeley, Calif. 1939

JONES, CHARLES B., Instructor in Forging and Heat Treating, Pratt Institute, Brooklyn, N. Y. 1928
JONES, DANIEL T., Professor and Head, Dept. of Industrial Engineering and Shops, Alabama Polytechnic Institute, Auburn, Ala. 1938
JONES, DOUGLAS K., Assistant Professor of Civil Engineering, University of Utah, Salt Lake City, Utah 1942
JONES, E. C., Assistant Professor of Shop Practice, Kansas State College, Manhattan, Kans. 1917
JONES, EDWARD N., President, Texas College of Arts and Industries, Kingsville, Texas 1942
JONES, EDWIN C., Associate Professor of Electrical Engineering, West Virginia University, Morgantown, W. Va. 1942
JONES, JAMES B., Professor and Head, Dept. of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1927
JONES, LAWRENCE D., Associate Professor of Engineering Drawing, Secretary, College of Engineering, Ohio State University, Columbus, Ohio 1939
JONES, LYNN W., Kaiser Co., Inc., Iron and Steel Div., Fontana, Calif. .. 1934
JONES, MERTON W., Instructor in Physics, Clarkson College of Technology, Potsdam, N. Y. 1942
JONES, PAUL G., Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1940
JONES, RALPH W., Assistant Professor of Mechanics, University of Delaware, Newark, Del. 1943
JONES, RICHARD W., Assistant Professor of Electrical Engineering, Northwestern University, Evanston, Ill. 1941
JONES, WEBSTER N., Director, College of Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1933
JONES, WILLIAM H., Associate Professor of Heat Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1935
JORDAN, HARVEY H., Professor and Head, General Engineering Drawing, and Associate Dean, College of Engineering, University of Illinois, Urbana, Ill. (*Vice President, 1931–32; Member of Council, 1924–7.*) 1915
JORDAN, HENRY G., Professor and Head, Dept. of Electrical Engineering, Colorado Agricultural College, Fort Collins, Colo. 1926
JORDAN, HERBERT E., Associate Professor of Mathematics, University of Kansas, Lawrence, Kans. 1924
JORDAN, WILLIAM, Assistant Professor of Electrical Engineering, Newark College of Engineering, Newark, N. J. 1940
JORGENSEN, ALBERT, Assistant Professor of General Engineering Drawing, University of Illinois, Urbana, Ill. 1926
JORGENSON, L. M., Associate Professor of Electrical Engineering, Kansas State College, Manhattan, Kans. 1926
JUDD, HORACE, Professor Emeritus of Mechanical Engineering, The Ohio State University, Columbus, O. 1907
JUDSON, WILLIAM J., Instructor in Engineering Drawing, University of Detroit, Detroit, Mich. **In military service** 1940
JURDAK, MANSUR, Professor of Mathematics, Director of Engineering Classes, American University of Beirut, Beirut, Syria. 1929
JUSTIN, EDWARD M., Assistant Professor of Mathematics, Case School of Applied Science, Cleveland, Ohio. **In military service** 1928
KALINSKE, ANTON A., Assistant Professor of Hydraulics, State University of Iowa, Iowa City, Iowa 1939

KAMMERMAN, J. O., Professor and Head, Dept. of Electrical Engineering, South Dakota State School of Mines, Rapid City, S. D. 1924
KAMMERMEYER, KARL, Publicker, Commercial Alcohol Co., Swanson & Mifflin, Philadelphia, Pa. 1939
KAMPMEIER, ROLAND A., Chief, Division of Power Economics, T. V. A., Power Bldg., Chattanooga, Tenn. 1939
KAPP, CECIL A., Director, Coöperative Education, Drexel Institute, Philadelphia, Pa. 1929
KARR, J. HAROLD, Assistant Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1939
KAUPPINEN, TENHO S., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. 1940
KAVANAUGH, DENNIS, JR., Professor of Mechanical Engineeiing, Post Graduate School, U. S. Naval Academy, Annapolis, Md. 1925
KAYAN, CARL F., Assistant Professor of Mechanical Engineering, Columbia University, New York City 1935
KEATON, L. D., Associate Professor of Industrial Education, East Texas State Teachers College, Commerce, Texas 1934
KEATOR, FREDERIC W., Assistant Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1929
KEBERNICK, OTTO C., Instructor in Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1942
KEELER, HUGH E., Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1926
KEENAN, JOSEPH H., Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1938
KEEVER, LEROY M., Associate Professor of Electrical Engineering, North Carolina State College, Raleigh, N. C. 1942
KEEVIL, CHARLES S., Professor and Head, Dept. of Chemical Engineering, Bucknell University, Lewisburg, Pa. 1936
KEGERREIS, ROY, Physician, 145 W. North Ave., Elmhurst, Ill. (Life Member.) 1913
KEHL, GEORGE L., Lecturer in Metallurgy, Columbia University, New York City 1941
KEITH, GERALD M., Assistant Professor of Civil Engineering, University of Florida, Gainesville, Fla. 1941
KEITH, HENRY H. W., Head, Dept. of Naval Architecture and Marine Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1940
KEITH, JESSE I., Professor and Head, Dept. of Food Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
KEITH, W. E., Assistant to Vice President, New England Tel. & Tel. Co., 50 Oliver St., Boston, Mass. 1939
KELLER, ARTHUR R., Dean, College of Applied Science, University of Hawaii, 2456 Oahn Avenue, Honolulu, T. H. 1910
KELLOGG, JOSEPH M., Professor and Head, Department of Architecture, University of Kansas, Lawrence, Kansas 1935
KELLS, LYMAN M., Associate Professor of Mathematics, U. S. Naval Academy, Annapolis, Md. 1942
KELLY, JOE W., Assistant Professor of Civil Engineering, University of California, Berkeley, Calif. 1940
KELSO, LESLIE E. A., Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1940
KEMLER, EMORY, Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1929

KEMMER, LLOYD H., RR No. 2, Harpers Road, New Haven, Ind. 1938
KENERSON, W. H., Professor of Mechanical Engineering, Emeritus, Brown University, Providence, R. I. (*Member of Council, 1924–7.*) 1903
KENNEDY, R. E., Secretary, American Foundrymen's Association, 222 West Adams St., Chicago, Ill. 1941
KENNY, FREDERICK J., Professor and Head, Dept. of Chemistry, St. Francis College, New York City 1934
KENRICK, GLEASON W., Professor of Physics, University of Porto Rico, Rio Pedras, P. R. 1927
KENT, BENJAMIN C., Professor of Engineering Drafting, University of Maine, Orono, Me. 1941
KENT, CLARENCE H., Associate Professor of Mechanical Engineering College of the City of New York, New York City 1939
KEPNER, HAROLD R., Professor of Civil Engineering, Utah State Agricultural College, Logan, Utah 1930
KERCHNER, RUSSELL M., Professor of Electrical Engineering, Kansas State College, Manhattan, Kans. 1923
KEREKES, FRANK, Professor of Structural Engineering, Iowa State College, Ames, Iowa 1927
KESLER, MACK S., Instructor in Civil Engineering, University of Utah, Salt Lake City, Utah 1942
KESNER, HENRY J., Professor of Civil Engineering, University of Nebraska, Lincoln, Nebr. 1921
KESSLER, LEWIS H., Associate Professor of Hydraulics and Sanitary Engineering, University of Wisconsin, Madison, Wis. 1937
KETCHUM, MILO S., JR., Assistant Professor of Structural Engineering, Case School of Applied Science, Cleveland, Ohio 1938
KEYES, DONALD B., Professor and Head, Division of Chemical Engineering, University of Illinois, Urbana, Ill. 1928
KIEFER, PAUL J., Professor of Mechanical Engineering, Post Graduate School, U. S. Naval Academy, Annapolis, Md. 1917
KIELY, EDMOND R., Professor of Engineering Drawing and Surveying, Iona College, New Rochelle, N. Y. 1942
KIERNAN, CHARLES J., Assistant Professor of Civil Engineering, Newark College of Engineering, Newark, N. J. 1931
KILCAWLEY, EDWARD J., Professor of Soil Mechanics and Sanitary Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1940
KILLIAN, J. R., Executive Assistant to President, Massachusetts Institute of Technology, Cambridge, Mass. 1939
KIMBALL, ALLEN H., Professor and Head, Department of Architectural Engineering, Iowa State College, Ames, Iowa 1931
KIMBALL, D. S., Emeritus, Professor of Mechanical Engineering, Cornell University, Ithaca, N. Y. (***President*, 1928–29; *Vice President*,** *1922–23; Member, Board of Investigation and Coördination, 1924–; Member of Council, 1928–.*) **Sixth Recipient Lamme Medal (1933).** 1915
KIMBALL, WM. P., Professor of Civil Engineering, Thayer School of Engineering, Hanover, N. H. 1933
KIMBARK, EDWARD W., Lecturer in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1936
KINDIG, C. H., Professor of Civil Engineering, Southwestern Louisiana Institute, Lafayette, La. 1939
KING, DAVID H., Instructor in General Engineering, Iowa State College, Ames, Iowa 1940

KING, EVERITT E., Professor of Railway Civil Engineering, University of Illinois, Urbana, Ill. 1908
KING, JOHN A., Professor and Head, Dept. of Mechanical Engineering, Syracuse University, Syracuse, N. Y. 1935
KING, MORLAND, Professor and Head, Dept. of Electrical Engineering, Lafayette College, Easton, Pa. (*Member of Council, 1932–35.*) ... 1920
KING, RICHARD, Instructor in Civil Engineering, University of Connecticut, Storrs, Conn. 1940
KING, ROBERT M., Associate Professor of Ceramic Engineering, The Ohio State University, Columbus, Ohio 1937
KING, ROY S., Head, Department of Mechanical Engineering, Georgia School of Technology, Atlanta, Ga. (*Vice President, 1924–5; Member of Council, 1920–5.*) 1904
KINGMAN, EDWARD D., Head, Department of Applied Mechanics, Wentworth Institute, Boston, Mass. 1923
KINGSLEY, CHARLES, Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1940
KINNEY, EDWARD D., Associate Professor of Metallurgical Engineering, University of Kansas, Lawrence, Kansas 1938
KINNEY, EDWARD E., Associate Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. 1925
KINNEY, GILBERT F., Head Instructor in Chemistry, Pratt Institute, Brooklyn, N.Y. **In military service** 1935
KINNEY, JOSEPH S., Assistant Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1936
KINSLOE, CHARLES L., Head, Department of Electrical Engineering, The Pennsylvania State College, State College, Pa. (*Member of Council, 1939–42.*) 1926
KINTNER, ROBERT C., Professor of Chemical Engineering, Illinois Institute of Technology, Chicago, Ill. 1934
KIPP, HAROLD L., Associate Professor of Mechanical Engineering, Texas Technological College, Lubbock, Texas. **In military service** 1938
KIRKPATRICK, SIDNEY D., Editor, Chemical and Metallurgical Engineering, 330 West 42nd St., New York City 1941
KISSAM, PHILIP, Associate Professor of Civil Engineering, Princeton University, Princeton, N. J. 1934
KISTLER, PAUL N., Associate Professor of Mechanical Engineering, Brown University, Providence, R. I. 1931
KITTREDGE, RAYMOND B., Professor of Transportation Engineering, State University of Iowa, Iowa City, Ia. 1921
KLEINSCHMIDT, R. B., Instructor in General Engineering, Rutgers University, New Brunswick, N. J. 1939
KLEMIN, ALEXANDER, Daniel Guggenheim Research Professor of Aeronautics, New York University, New York City 1926
KLOEFFLER, ROYCE G., Professor and Head, Department of Electrical Engineering, Kansas State College, Manhattan, Kans. 1919
KNAEBEL, CARL H., Assistant Professor of Mathematics, Michigan College of M. & T., Houghton, Mich. 1940
KNAPP, WILLARD A., Assistant Dean of Engineering, Purdue University, Lafayette, Ind. 1920
KNIFFEN, ALLEN T., Instructor in Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1937
KNIGHT, ABNER R., Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1929

KNIGHT, ARTHUR J., Professor and Acting Head, Dept. of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1926
KNIGHT, ODON S., Assistant Professor of Chemical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1941
KNIGHT, RAYMOND M., Instructor in Mathematics, Wentworth Institute, Boston, Mass. 1942
KNIGHT, W. A., Professor of Mechanical Practice, Emeritus, The Ohio State University, Columbus, O. 1907
KNIGHTS, FREDERICK J., Assistant Professor of Industrial Engineering, Thayer School of Engineering, Hanover, N. H. 1942
KNIPMEYER, CLARENCE C., Professor of Electrical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1929
KNOLL, HORTON B., Assistant Professor of English, Purdue University, Lafayette, Ind. 1940
KNOWLES, MAHLON G., Instructor in Applied Science, Wentworth Institute, Boston, Mass. 1922
KNUDSON, CLARENCE M., Dean, School of Engineering, University of Denver, Denver, Colo. 1941
KOCH, RUTH L., Cashier, University of Louisville, Louisville, Ky. 1927
KOEHLER, W. A., Professor of Chemical and Ceramic Engineering, West Virginia University, Morgantown, W. Va. 1936
KOENIG, LLOYD R., Assistant Professor of Mechanical Engineering, Washington University, St. Louis, Mo. 1931
KOENIG, LOUIS A., Assistant Professor of Chemistry and Chemical Engineering, A. & M. College of Texas, College Station, Texas 1937
KOENITZER, LESTER H., Associate Professor of Applied Mechanics, Kansas State College, Manhattan, Kans. 1929
KOEPKE, CHARLES A., Administrative Assistant, University of Minnesota, Minneapolis, Minn. 1929
KOERBER, G. A., Professor of Electrical Engineering, University of Delaware, Newark, Del. 1915
KOFFOLT, JOSEPH H., Professor of Chemical Engineering, The Ohio State University, Columbus, Ohio 1933
KOHLER, ARTHUR S., Assistant Professor of Chemistry, Newark College of Engineering, Newark, N. J. 1932
KOHLER, HENRY L., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. **In military service** 1940
KOLB, ROBERT P., Professor of Heat-Power Engineering, Worcester Polytechnic Institute, Worcester, Mass. **In military service** 1925
KOLB, WILLIAM K., Industrial Engineer, Ford, Bacon & Davis, 151 Center St., Chatham, N. J. 1937
KOMAREWSKY, VASILI T., Professor of Chemistry, Illinois Institute of Technology, Chicago, Ill. 1941
KOMMERS, JESSE B., Professor of Mechanics, University of Wisconsin, Madison, Wis. 1923
KONOVE, CARL, Instructor in Mathematics, Newark College of Engineering, Newark, N. J. 1941
KOOPMAN, RICHARD J. W., Associate Professor of Electrical Engineering, University of Kansas, Lawrence, Kans. 1939
KOTH, ARTHUR W., Assistant Professor of Chemical Engineering, University of North Dakota, Grand Forks, N. D. 1935
KOUWENHOVEN, WILLIAM B., Dean, School of Engineering, Professor of Electrical Engineering, The Johns Hopkins University, Baltimore, Md. 1938

KOVARIK, ALOIS F., Professor of Physics, Yale University, New Haven, Conn. 1919
KOWALKE, OTTO L., Professor of Chemical Engineering, University of Wisconsin, Madison, Wis. 1918
KOZACKA, JOSEPH S., Associate Professor of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1938
KRAEHENBUEHL, JOHN O., Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1940
KRATHWOHL, WM. C., Professor of Mathematics, Director, Dept. of Educational Tests and Measurements, Illinois Institute of Technology, Chicago, Ill. 1927
KRAYBILL, EDWARD K., Instructor in Electrical Engineering, Duke University, Durham, N. C. 1940
KREFELD, WILLIAM J., Associate Professor of Civil Engineering, Columbia University, New York City 1929
KREYDICH, WALTER, Instructor in Electrical Engineering, South Dakota School of Mines, Rapid City, S. D. 1941
KRIEGEL, WILLIAM W., Assistant Professor of Ceramic Engineering, North Carolina State College, Raleigh, N. C. 1939
KROEGER, HENRY R., Assistant Professor of Mechanical Engineering, University of Oklahoma, Norman, Okla. 1942
KRYNINE, D. P., Research Associate in Soil Mechanics, Yale University, New Haven, Conn. 1934
KUETHE, ARNOLD M., Associate Professor and Acting Chairman, Dept. of Aeronautical Engineering, University of Michigan, Ann Arbor, Mich. 1942
KUHLEN, FREDERICK, Associate Professor and Chairman, Dept. of Mechanical Engineering, College of the City of New York, New York City 1935
KUHLMAN, JOHN H., Associate Professor of Electrical Design, University of Minnesota, Minneapolis, Minn. 1925
KULP, MARK R., Associate Professor of Agricultural Engineering, Irrigationist, Agricultural Experiment Station, University of Idaho, Moscow, Ida. 1934
KUNKLE, GEORGE M., Assistant Professor of Mechanical Engineering, Bucknell University, Lewisburg, Pa. 1925
KUNZ, RAYMOND J. F., Assistant Professor of Chemical Engineering, Northwestern University, Evanston, Ill. 1940
KURTZ, E. B., Professor and Head, Department of Electrical Engineering, University of Iowa, Iowa City, Iowa 1921
KURTZ, JOHN W., Head, Engineering Department, Municipal University of Omaha, Omaha, Nebr. 1934
KURZWEIL, ARTHUR C., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. 1940
KUT, WALTER S., Instructor in Mechanical Engineering, Cooper Union, New York City. **In military service** 1938
KYLE, P. E., Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1939
LABBERTON, JOHN M., Associate Professor of Mechanical Engineering, New York University, New York City 1937
LADNER, A. COLLINS, Assistant Professor of Mathematics and Engineering Science, Denison University, Granville, Ohio 1934
LAESTADIUS, JOHN E., Instructor in Physics, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1942

LAGAARD, M. B., Assistant Professor of Civil Engineering, Northwestern University, Evanston, Ill. 1942
LAITALA, EVERETT, Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. 1941
LAKE, WILFRED S., Professor of Economics, Dean, College of Liberal Arts, Northeastern University, Boston, Mass. 1939
LAMB, JOHN F., Assistant Professor of Electrical Engineering, University of Missouri, Columbia, Mo. 1937
LAMBE, CLAUDE M., Instructor in Civil Engineering, North Carolina State College, Raleigh, N. C. 1939
LAMBE, EMERSON P., Acting Head, Dept of Physics, Pratt Institute, Brooklyn, N. Y. 1926
LAMBERT, B. J., Professor and Head, Dept. of Civil Engineering, State University of Iowa, Iowa City, Ia. 1907
LAMBERT, LEROY S., Assistant to the President, Northwestern Bell Telephone Company, 1204 Telephone Building, Omaha, Neb. 1929
LAMBERTINE, JOSEPH A., Assistant Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1928
LAMBIE, JOS. S., Director, E. S. M. W. T., Lecturer in Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914
LAMPE, JOHN H., Dean of Engineering, Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. 1938
LANCASTER, FORREST W., Associate Professor of Physics, North Carolina State College, Raleigh, N. C. 1937
LANCOUR, HAROLD, Librarian and Assistant Professor of Bibliography, The Cooper Union, New York City 1942
LANDON, RANSOM D., Professor of Civil Engineering, Southern Methodist University, Dallas, Texas 1937
LANE, DONALD F., Director of Training, Bethlehem Steel Co., Sparrows Point, Md. 1939
LANE, EMORY W., Professor of Hydraulic Engineering, State University of Iowa, Iowa City, Iowa. **In military service** 1935
LANE, RUTH McG., Librarian, Vail Library, Massachusetts Institute of Technology, Cambridge, Mass. 1941
LANGDON, HOWARD H., Professor and Head, Dept. of Mechanical Engineering, Washington State College, Pullman, Wash. 1936
LANGE, ERNEST O., Associate Professor of Electrical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937
LANGENHEIM, RALPH L., Dean of Engineering and Vice President, University of Tulsa, Tulsa, Okla. 1938
LANGILLE, H. B., Associate Professor of Mechanical Engineering, Emeritus, University of California, Berkeley, Calif. 1915
LANGSDORF, ALEXANDER S., Dean, Schools of Engineering and Architecture, Washington University, St. Louis, Mo. (*Member of Council, 1913–16.*) 1903
LANGSNER, ADOLPH, Professor of Management, Northwestern University; Factory Manager, Eugene Dietzen Co., Chicago, Ill. 1938
LANING, WILLARD A., Engineer, Westinghouse E. & M. Co., Electronics Eng. Div., Bloomfield, N. J. 1930
LANSFORD, WALLACE M., Assistant Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1935
LANSIL, CLIFFORD E., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1925
LARGE, GEORGE E., Professor of Civil Engineering, The Ohio State University, Columbus, Ohio 1940

LARIAN, MAURICE G., Associate Professor of Chemical Engineering, Michigan State College, East Lansing, Mich. 1937

LARK-HOROVITZ, K., Professor and Head, Dept. of Physics, Purdue University, Lafayette, Ind. 1942

LARKIN, F. V., Director of Mechanical Engineering, Lehigh University, Bethlehem, Pa. (*Member of Council, 1930–33; Vice President, 1933–34.*) 1912

LARKIN, JOHN D., Professor and Chairman, Dept. of Political Science, Illinois Institute of Technology, Chicago, Ill. 1939

LARSEN, MERWIN J., Assistant Professor of Electrical Engineering, Michigan College of M. & T., Houghton, Mich. 1938

LARSON, ALVIN, Civil Engineering Dept., Gulf Oil Co., 529 Ave. K., Boulder City, Nev. 1938

LARSON, C. WILLIAM, Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1929

LARSON, G. L., Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. 1911

LARSON, LUDVIG C., Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1937

LARSON, REINHOLD F., Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1939

LARUE, HARRY A., Associate Professor of Civil Engineering, University of Missouri, Columbia, Mo. 1939

LASSALLE, LEO J., Professor of Engineering Mechanics, Dean, College of Engineering, Louisiana State University, University, La. 1935

LATIMER, CLARA A., Assistant Professor of Civil Engineering, University of Utah, Salt Lake City, Utah 1940

LAUER, BRYON E., Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. **In military service** 1937

LAURENCE, JACQUES, Assistant Professor of Electrical Engineering, Ecole Polytechnique, Montreal, Canada 1942

LAURSON, PHILIP G., Associate Professor of Engineering Mechanics, Yale University, New Haven, Conn. 1920

LAVINE, IRVIN, Sec. Treas., Industrial Research Service, Masonic Bldg., Dover, N. H. 1935

LAWALL, CHARLES E., President, West Virginia University, Morgantown, W. Va. (*Member of Council, 1942–45.*) 1931

LAWLER, LEO T., Associate Professor of English, Carnegie Institute of Technology, Pittsburgh, Pa. 1937

LAY, WALTER E., Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1940

LAYTON, WILLIAM I., Instructor in Engineering and Mathematics, Amarillo Junior College, Amarillo, Texas 1941

LEAR, JOHN E., Professor of Electrical Engineering, North Carolina State College, Raleigh, N. C. 1938

LEASE, L. J., Industrial Coordinator, Illinois Institute of Technology, Chicago, Ill. 1939

LEBLANC, FERNAND, Assistant Professor of Electrical Engineering, Ecole Polytechnique, Montreal, Canada 1942

LEE, CLAUDIUS, Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1935

LEE, GEORGE H., Instructor in Mechanics, Carnegie Institute of Technology, Pittsburgh, Pa. 1941

LEE, ROLAND L., Professor and Head, Textile Engineering, Texas Technological College, Lubbock, Texas. (1616 Sonial St., New Orleans, La.) 1940
LEES, JAMES W., Dean, Lincoln Technical Institute, Boston, Mass. 1942
LEFAVOUR, ROLAND W., Assistant Professor of Civil Engineering, Tufts College, Medford, Mass. 1921
LEFEBVRE, OLIVIER O., Vice President, Quebec Streams Commission, New Court House, Montreal, Canada 1919
LEGAULT, ADRIAN R., Assistant Professor of Civil Engineering, Colorado State College, Ft. Collins, Colo. 1940
LEGGET, ROBERT F., Assistant Professor of Civil Engineering, University of Toronto, Toronto, Ont. 1940
LEHMAN, L. GRAHAM, Instructor, Electric Power and Maintenance, Pittsburgh Public Schools, 813 Franklin Ave. (21), Pittsburgh, Pa. 1939
LEHMANN, CHARLES H., Instructor in Mathematics, Cooper Union, New York City 1941
LEHMANN, EMIL W., Professor and Head, Department of Agricultural Engineering, University of Illinois, Urbana, Ill. 1935
LEHOCZKY, PAUL N., Associate Professor of Industrial Engineering, Ohio State University, Columbus, Ohio 1930
LEIGHTON, ARTHUR W., Associate Professor of Engineering Drawing, Freshman Advisor, Tufts College, Medford, Mass. 1922
LEISTER, JOHN S., Associate Professor of Civil Engineering, The Pennsylvania State College, State College, Pa. **In military service** 1934
LEKBERG, HOWARD P., Instructor in Mechanical Engineering, University of Maine, Orono, Maine 1938
LELAND, O. M., Dean of Administration, Institute of Technology, University of Minnesota, Minneapolis, Minn. (*President, 1926–7; Member of Council, 1921–4; 1926–.*) 1908
LENDALL, HARRY N., Professor and Head, Dept. of Civil Engineering, Rutgers University, New Brunswick, N. J. 1912
LENG, RICHARD B., Senior Process Engineer, RCA Mfg. Co., Lancaster, Pa. 1937
LENZ, ARNO T., Assistant Professor of Hydraulic Engineering, University of Wisconsin, Madison, Wis. 1938
LEO, BROTHER AMANDUS, Dean of Engineering, Manhattan College, New York City 1928
LEONARD, CARROLL M., Associate Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1930
LEONARD, HEMAN BURR, Professor and Head, Dept. of Mathematics, University of Arizona, Tucson, Ariz. 1919
LEONARD, PAUL B., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1941
LEONARD, SAMUEL J., Associate Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1928
LEPAGE, CLIFFORD B., Assistant Secretary, The American Society of Mechanical Engineers, 29 West 39th St., New York City 1908
LERNER, SAMUEL, Instructor in Civil Engineering, Brown University, Providence, R. I. 1941
LESTER, BERNARD, Sales Executive, Westtinghouse E. & M. Co., 40 Wall St., New York City 1936
LESTER, OLIVER C., Professor of Physics, Vice President and Dean of Graduate School, Emeritus; Indiana University, Bloomington, Ind. 1912
LETELLIER, L. S., Head, Dept. of Engineering, Professor of Civil Engineering, The Citadel, Charleston, S. C. 1912

LEUTWILER, O. A., Professor and Head, Department of Mechanical Engineering, University of Illinois, Urbana, Ill. (*Member of Council, 1918–21.*) 1906
LEUTWILER, RICHARD W., Assistant Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1941
LEVINE, JACK, Associate Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1940
LEWELLEN, MARCY T., Professor and Head, Dept. of Mechanical Engineering, University of New Mexico, Albuquerque, N. M. 1938
LEWIS, FRED J., Dean, School of Engineering, Vanderbilt University, Nashville, Tenn. 1926
LEWIS, J. F., Assistant Engineer, U. S. Navy Yard, 505 Brinton St., Germantown, Philadelphia, Pa. (Life Member.) 1913
LEWIS, RALPH E., Assistant Professor of Mechanical Engineering, Duke University, Durham, N. C. 1931
LEWIS, ROBERT L., Assistant Professor of Civil Engineering, Colorado State College, Ft. Collins, Colo. 1939
LEWIS, ROBERT S., Professor of Mining, University of Utah, Salt Lake City, Utah 1922
LEWIS, WARREN K., Professor of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1932
LEWIS, WILLIAM A., Director, School of Electrical Engineering, Cornell University, Ithaca, N. Y. 1939
LEWIS, WILLIAM D., Librarian, Memorial Library, University of Delaware, Newark, Del. 1941
LEWISOHN, SAM A., Vice President and Treasurer, Miami Copper Company, 61 Broadway, New York City 1929
LICHTY, LESTER C., Associate Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1930
LICKEY, HARRY F., Associate Professor of Communication Engineering, Washington State College, Pullman, Wash. 1936
LIDDICOAT, RICHARD T., Assistant Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. 1940
LIGHT, J. J., Assistant Professor of Mechanical Engineering, Pennsylvania State College, State College, Pa. 1917
LIGHTBURN, FRANK E., Associate Professor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa. **In military service** .. 1937
LILLY, SCOTT B., Professor of Civil Engineering and Chairman, Division of Engineering, Swarthmore College, Swarthmore, Pa. 1913
LIND, SAMUEL C., Dean, Institute of Technology, University of Minnesota, Minneapolis, Minn. 1935
LINDAHL, ERIC J., Assistant Professor of Mechanical Engineering, The Ohio State University, Columbus, Ohio 1941
LINDELL, W. FRANCIS, Assistant Professor of Mechanical Engineering, University of Delaware, Newark, Del. 1941
LINDEMAN, MARVEL F., Assistant Professor of Civil Engineering, Wayne University, Detroit, Mich. 1938
LINDEMANN, ABERT J., 8314 Carey Lane, Silver Springs, Md. **In military service** 1939
LINDLEY, ROY W., Associate Professor of Practical Mechanics, Purdue University, Lafayette, Ind. 1922
LINDSAY, FRANK B., Assistant Chief, Div. of Secondary Education, California State Dept. of Education, P.O. Box 25, Sacramento, Calif .. 1928
LINDSAY, JAMES D., Professor and Head, Dept. of Chemical Engineering, A. & M. College of Texas, College Station, Texas 1936

LINDSAY, LOUIS, Professor and Chairman, Dept. of Applied Mathematics, Syracuse University, Syracuse, N. Y. 1941
LINDSENMEYER, FRANCIS J., Director of Mechanical Engineering, University of Detroit, Detroit, Mich. 1940
LINDVALL, FREDERICK C., Associate Professor of Electrical and Mechanical Engineering, California Institute of Technology, Pasadena, Calif. 1941
LINGEMAN, CYRIL A., Instructor in English, University of Detroit, Detroit, Mich. 1941
LITKENHOUS, EDWARD E., Professor and Head, Dept. of Chemical Engineering, Vanderbilt University, Nashville, Tenn. 1936
LITTLE, WALTER B., Instructor in General Engineering, University of Washington, Seattle, Wash. 1937
LITTLETON, EARLE F., Assistant Professor of Civil Engineering, Tufts College, Medford, Mass. 1938
LIUM, ELDER L., Associate Professor of Civil Engineering, University of North Dakota, Grand Forks, N. D. 1940
LIVINGOOD, MARVIN D., Instructor in Chemical Engineering, Missouri School of Mines, Rolla, Mo. 1941
LIWSCHITZ-GARIK, MICHAEL, Adjunct Professor of Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1942
LLOYD, HAROLD RHYS, Associate Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1926
LOCKE, CHARLES E., Professor Emeritus of Mining Engineering and Ore Dressing, Massachusetts Institute of Technology, Alumni Secretary, Cambridge, Mass. 1924
LOCKE, WILLIAM W., JR., Assistant Professor of Electrical Engineering, Supt. of Dormitory, Worcester Polytechnic Institute, Worcester, Mass. 1934
LOCKWOOD, HAROLD J., Professor and Head, Dept. of Electrical Engineering, Manhattan College, New York City 1938
LOEW, EDGAR A., Dean, College of Engineering, Professor of Electrical Engineering, University of Washington, Seattle, Wash. 1936
LOFGREN, KENNETH E., Assistant Professor of Machine Design, Cooper Union, New York City 1936
LOHR, WM. S., Professor and Head, Dept. of Civil Engineering, Lafayette College, Easton, Pa. 1927
LOMMEL, GEORGE E., Professor of Topographical Engineering, Purdue University, Lafayette, Ind. 1926
LONDON, ALEXANDER L., Assistant Professor of Mechanical Engineering, Stanford University, Palo Alto, Calif. 1940
LONG, JAMES D., Acting Research Director, Douglas Fir Plywood Assn., Tacoma, Wash. 1932
LONG, MAURICE B., Assistant to Vice President, Bell Telephone Laboratories, 463 West Street, New York, N. Y. 1930
LOONEY, CHARLES T. G., Assistant Professor of Civil Engineering, State University of Iowa, Iowa City, Iowa 1937
LORAH, JAMES R., Associate Professor of Chemical Engineering, University of Missouri, Columbia, Mo. 1928
LOTT, ARWYNE O., Switchgear Test, Westinghouse E. & M. Co., 887 Peachtree St., N.E., Atlanta, Ga. 1941
LOUTHAN, M. RICHARDS, Professor of Mathematics, Bluefield Junior College, Bluefield, Va. 1940
LOVELL, ALFRED H., Assistant Dean and Secretary, College of Engineering, Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1920

LOVELL, CLIFTON L., Associate Professor of Chemical Engineering, Purdue University, Lafayette, Ind. 1936

LOVELL, WILLIAM E., Professor of Electrical Engineering, University of Saskatchewan, Saskatoon, Sask. 1937

LOVETT, I. H., Professor of Electrical Engineering, University of Missouri, Rolla, Mo. 1921

LOVING, ROBERT O., Assistant Professor of Technical Drawing, Illinois Institute of Technology, Chicago, Ill. 1942

LOWE, THOMAS M., Professor and Head, Dept. of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1928

LUCARINI, GENO B., Assistant Professor of Mechanical Engineering, University of Vermont, Burlington, Vt. 1929

LUCAS, ERNEST L., Professor of Mechanical Engineering, Mississippi State College, State College, Miss. **In military service** 1939

LUCE, ALEXANDER W., Mechanical Engineer, The Fellows Gear Shaper Co., Springfield, Vt. 1932

LUDDEN, DWIGHT J., Director, Vocational Dept., Community High School, Granite City, Ill. **In military service** 1933

LUDT, RANDALL W., Assistant Professor of Chemical Engineering, Michigan State College, East Lansing, Mich. 1939

LUDWICKSON, JAMES K., Instructor in Mechanical Engineering, University of Nebraska, Lincoln, Nebr. 1938

LUDY, L. V., Professor of Experimental Engineering, Purdue University, Lafayette, Ind. 1902

LUEBBERS, R. H., Assistant Professor of Chemical Engineering, University of Missouri, Columbia, Mo. (Med. Insp., Station Hospital, Camp San Luis Obispo, Calif.) 1939

LUEBS, AUGUST A., Associate Professor of Mechanical Engineering, University of Nebraska, Lincoln, Nebr. 1921

LUETH, IRVING B., Instructor in Electrical Engineering, Pratt Institute, Brooklyn, N. Y. 1931

LUKE, CHARLES D., Professor and Head, Department of Chemical Engineering, Syracuse University, Syracuse, N. Y. **In military service** 1939

LUKENS, HIRAM S., Director, Department of Chemistry and Chemical Engineering, University of Pennsylvania, Philadelphia, Pa. 1935

LUNDE, OTTO H., Professor and Head, Dept. of Aeronautical Engineering, University of Alabama, University, Ala. **In military service** 1940

LURIE, ARNOLD N., Head, Drawing Department, Tilden Technical High School, Chicago, Ill. 1933

LUTHER, H. B., Professor of Civil Engineering, University of Cincinnati, Cincinnati, O. 1914

LUTZ, SAMUEL G., Physicist, Naval Research Lab., 2043 38th St., S.E., Washington, D. C. 1939

LYNCH, W. S., Professor in Charge of Humanities, Cooper Union, New York City 1939

LYTLE, CHAS. W., Associate Professor of Industrial Engineering, New York University, New York City 1922

MABIE, HAMILTON H., Instructor in Industrial Engineering, Cornell University, Ithaca, N. Y. 1941

MACALPINE, DAVID M., Instructor in Civil Engineering, College of the City of New York, New York City 1936

MACCULLOUGH, GLEASON H., Professor of Engineering Mechanics, Worcester Polytechnic Institute, Worcester, Mass. 1922

MACDONALD, JAMES K. L., Assistant Professor of Mathematics, Cooper Union, New York City 1940

MACEDO, G. MORALES, Director of Industries in Peru, 205 Tupac Amaro, San Isidro, Lima, Peru 1940
MACFADYEN, K. A., Instructor in Mechanical Engineering, Newark College of Engineering, Newark, N. J. 1941
MACHWART, GEORGE M., Assistant Professor of Chemical Engineering, Michigan College of M. & T., Houghton, Mich. 1941
MACK, ALBERT J., Professor of Mechanical Engineering, Kansas State College, Manhattan, Kans. 1919
MACKAY, ERNEST, Assistant Professor of Mathematics, Ecole Polytechnique, Montreal, Canada 1942
MACKAY, SCOTT, Professor of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1936
MACKENZIE, C. J., University of Saskatchewan, Saskatoon, Canada 1915
MACKEY, CHARLES O., Professor of Heat Power Engineering, Cornell University, Ithaca, N. Y. 1942
MACKINNON, JOSEPH C., Registrar, Massachusetts Institute of Technology, Cambridge, Mass. 1939
MACLEAN, EDWARD A., Professor and Head, Dept. of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1937
MACLEAN, JOHN A., Assistant Chief Engineer, Aircraft Landing Gear Eng., Bendix Aviation Corp., South Bend, Ind. 1934
MACLIN, EDWARD S., President, West Virginia Institute of Technology, Montgomery, W. Va. 1922
MACNAUGHTON, EDGAR, Professor of Mechanical Engineering, Tufts College, Medford, Mass. 1916
MACQUIGG, CHARLES E., Dean of Engineering College, Director, Engineering Experiment Station, The Ohio State University, Columbus, Ohio. *(First Vice President, 1942–43; Member of Council, 1939–40.)* 1937
MAGOUN, F. ALEXANDER, Associate Professor of Humanics, Massachusetts Institute of Technology, Cambridge, Mass. 1930
MAHANEY, JOHN P., Associate Professor of Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1939
MAHIN, EDWARD G., Professor and Head, Dept. of Metallurgy, University of Notre Dame, Notre Dame, Ind. 1939
MAIN, CHARLES T., Chairman, Chas. T. Main, Inc., 201 Devonshire St., Boston, Mass. 1911
MAINARDI, POMPEY, Instructor in Mathematics, Newark College of Engineering, Newark, N. J. 1935
MAINS, LAURENCE P., Assistant Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937
MALAKOFF, HOWARD L., Chemicals Div., Cities Service Oil Co., Tallant, Okla. 1941
MALCOLM, W. L., Director, School of Civil Engineering, Cornell University, Ithaca, N. Y. 1934
MALLORY, DONALD D., Professor and Head, Dept. of Engineering, Valparaiso University, Valparaiso, Ind. 1941
MALLORY, FRANCIS, Professor of Physics, Emeritus, Virginia Military Institute, Lexington, Va. 1912
MALTBY, LEON L., Instructor in Applied Mathematics, Syracuse University, Syracuse, N. Y. 1941
MANDERFIELD, NICHOLAS H., Professor of Mineral Dressing, Michigan College of M. & T., Houghton, Mich. 1937
MANEY, GEORGE A., Chairman, Dept. of Civil Engineering, Northwestern University, Evanston, Ill. 1938

MANGOLD, JOHN F., Associate Professor of Mechanics, Illinois Institute of Technology, Chicago, Ill. 1941

MANIFOLD, GEORGE O., Instructor in Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. **In military service** 1939

MANN, CAROLL L., Professor and Head, Dept. of Civil Engineering, North Carolina State College, Raleigh, N. C. 1937

MANN, CHARLES A., Chief of Division and Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minn. 1917

MANN, CLAIR V., Professor and Head, Dept. of Engineering Drawing, University of Missouri, Rolla, Mo. (*Member of Council, 1925–8.*) .. 1924

MANNING, HERBERT L., Wage and Salary Administrator, Pratt & Whitney Co., East Hartford, Conn. 1939

MANNING, MELVIN L., Associate Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1940

MARA, HUBERT W., Associate Professor of Drawing and Mathematics, Norwich University, Northfield, Vt. 1939

MARCHANT, GUY B., Associate Professor of Electrical Engineering, Evansville College, Evansville, Ind. 1927

MARCO, SALVATORE M., Assistant Professor of Mechanical Engineering, The Ohio State University, Columbus, Ohio 1937

MARIN, AXEL, Associate Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1941

MARIN, JOSEPH, Professor of Engineering Mechanics, The Pennsylvania State College, State College, Pa. 1931

MARKLE, E. W., Professor of Electrical Engineering, A. & M. College of Texas, College Station, Tex. 1923

MARKLE, GERALD E., Instructor in Mathematics, University of Detroit, Detroit, Mich. 1941

MARKOWITZ, JESSE, Instructor in Drafting, College of the City of New York, New York City 1940

MARLIES, CHARLES A., Assistant Professor of Chemical Engineering, College of the City of New York, New York City 1940

MARMO, E. JOSEPH, Assistant Professor of Engineering Mechanics, University of Nebraska, Lincoln, Nebr. 1940

MARQUIS, F. W., Professor and Chairman, Dept. of Mechanical Engineering, The Ohio State University, Columbus, Ohio. (*Member of Council, 1936–39.*) 1910

MARSHALL, OSCAR J., Associate Professor of Civil Engineering, The Ohio State University, Columbus, Ohio 1940

MARSTON, ANSON, Dean of Engineering, Emeritus, Iowa State College, Ames, Ia. (*President, 1914–5; Treasurer, 1906–7; Member of Council, 1914–.*) **Fourteenth Recipient, Lamme Medal (1941).** ... 1894

MARSTON, GEORGE A., Assistant Professor of Civil Engineering, Massachusetts State College, Amherst, Mass, ... 1938

MARTENIS, JOHN V., Associate Professor Emeritius, University of Minnesota, 4800 Bloomington Ave., Minneapolis, Minn. 1908

MARTIN, BRUCE W., Instructor in Engineering, Los Angeles City College, 10409 Bloomfield, No. Hollywood, Calif. 1933

MARTIN, CHARLES E., Instructor in Welding, Illinois Institute of Technology, Chicago, Ill. 1942

MARTIN, F. F., Industrial Relations Dept., Kimberly Clark Corp., Neenah, Wis. 1939

MARTIN, FRANK L., Professor of Physics, Pennsylvania Military College, Chester, Pa. 1938

MARTIN, JOSEPH J., Instructor in Chemical Engineering, University of Rochester, Rochester, N. Y. 1941
MARTIN, W. H., Professor of Heat Engineering, Oregon State College, Corvallis, Ore. 1913
MASK, FRANCIS E., du Pont Powder Co., P.O. Box 955, Joliet, Ill. 1939
MASON, HIRAM R., Professor of Electrical Engineering, Southwestern Louisiana Institute, Lafayette, La. 1939
MASON, HOWARD W., Professor of Mechanical Engineering, Georgia School of Technology, Atlanta, Ga. 1927
MASON, JESSE W., Professor and Head, Dept. of Chemical Engineering, Georgia School of Technology, Atlanta, Ga. 1935
MASON, MAYNE S., Member Laboratories Staff, Bell Telephone Labs., Inc., 463 West St., New York City 1939
MASON, WENDELL E., Associate Professor of Applied Mathematics, University of California at Los Angeles, Calif. 1939
MASSEY, JOE T., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1940
MASSON, HENRY J., Assistant Dean, College of Engineering, New York University, New York City 1935
MATHEWSON, CHAMPION H., Professor of Metallurgy, Yale University, New Haven, Conn. 1921
MATHEWSON, EDWARD P., Professor of Administration of Mineral Industry, University of Arizona, Tucson, Ariz. 1932
MATSON, RAY M., Professor and Head, Dept. of Mechanical Engineering, Southern Methodist University, Dallas, Texas 1937
MATTHES, GEORGE F., Associate Professor of Electrical Engineering, Louisiana State University, University, La. 1935
MATTING, FRED W., Instructor in Mechanical Engineering, Kansas State College, Manhattan, Kansas 1940
MATZKE, ARTHUR E., Research Assistant in Civil Engineering, Columbia University, New York City 1936
MAUFETTE, PIERRE, Assistant Professor of Mineralogy and Geology, Ecole Polytechnique, Montreal, Canada 1942
MAUGH, LAWRENCE C., Assistant Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. 1940
MAURER, EDWARD R., Professor of Mechanics, (Emeritus) University of Wisconsin, Madison, Wis. (*Vice President, 1918–9; Member of Council, 1909–12.*) **Seventh Recipient Lamme Medal (1934).** 1897
MAURER, ROBERT L., Instructor in English, Oregon State College, Corvallis, Ore. **In military service** 1941
MAUTE, BERNHARD W., Instructor in Machine Design, U. S. Military Academy, West Point, N. Y. 1941
MAVIS, FREDERIC T., Professor and Head, Dept. of Civil Engineering, The Pennsylvania State College, State College, Pa. 1929
MAXFIELD, HAROLD A., Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. **In military service** 1925
MAXWELL, FRED R., JR., Professor of Electrical Engineering, University of Alabama, University, Ala. **In military service** 1934
MAY, JAMES W., Associate Professor of Heating and Ventilation, University of Kentucky, Lexington, Ky. 1938
MAYER, JOHN K., Associate Professor and Head, Dept. of Experimental Engineering, Tulane University, New Orleans, La. 1937
MAYROSE, HERMAN E., Professor of Engineering Mechanics, University of Detroit, Detroit, Mich. 1940

McAdams, William H., Professor of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1932
McCaffery, Richard S., Consulting Metallurgist, 163 W. 194th St., New York, N. Y. 1937
McCain, Dewey M., Professor and Head, Dept. of Civil Engineering, Mississippi State College, State College, Miss. 1933
McCandliss, L. C., Professor and Head, Dept. of Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. 1914
McCarthy, James A., Assistant Professor of Civil Engineering, University of Notre Dame, Notre Dame, Ind. 1939
McCaskey, A. E., Head, Dept. of Engineering, Marshall College, Huntington, W. Va. **In military service** 1936
McClain, Fred H., Associate Professor of Electrical Engineering, Iowa State College, Ames, Ia. 1921
McClelland, E. H., Technology Librarian, Carnegie Library of Pittsburgh, Pittsburgh, Pa. 1912
McClintock, Edwin C., Instructor in English, University of Virginia, University, Va. 1939
McClure, Oscar E., Associate Professor of Physics and Electrical Engineering, Ohio University, Athens, Ohio 1937
McCombs, Glenn C., Assistant Professor of Engineering Drawing and Descriptive Geometry, Carnegie Institute of Technology, Pittsburgh, Pa. 1934
McConnell, Robert K., Instructor in Engineering Drawing, New York University, New York City 1942
McCormack, Harry, Professor and Director, Department of Chemical Engineering, Illinois Institute of Technology, Chicago, Ill. 1935
McCormack, Ralph H., Instructor in Chemical Engineering, Pratt Institute, Brooklyn, N. Y. **In military service** 1937
McCoy, James E., Head, Dept. of Chemistry, Bluefield Junior College, Bluefield, Va. 1940
McCrumm, John D., Assistant Professor of Electrical Engineering, Swarthmore College, Swarthmore, Pa. 1936
McCullough, F. M., Professor and Head, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1910
McCully, Harry M., Professor and Head, Dept. of Drawing, Carnegie Institute of Technology, Pittsburgh, Pa. 1926
McCully, Harry M., Jr., Instructor in Graphics and Engineering Drawing, Princeton University, Princeton, N. J. 1939
McCurdy, Henry B., Editor and Assistant Manager, College Dept. Macmillan Company, 60 5th Avenue, New York City 1936
McDaniel, J. E., Professor and Director of Coöperative Courses, Georgia School of Technology, Atlanta, Ga. (*Member of Council, 1930–33.*) 1926
McDonald, Philip B., Professor of English, New York University, University Heights, New York, N. Y. 1917
McElroy, D. Lee, Director, School of Mines, West Virginia University, Morgantown, W. Va. 1938
McFarlan, Harold J., Assistant Professor of Geodesy and Surveying, University of Michigan, Ann Arbor, Mich. 1941
McFarland, James D., Assistant Professor of Drawing, University of Texas, Austin, Texas 1938
McFarland, Reginald A., Professor of Civil Engineering, Louisiana Polytechnic Institute, Ruston, La. 1939
McGehee, William, Associate Professor and Head, Dept. of Psychology, North Carolina State College, Raleigh, N. C. **In military service** 1941

McGIVERN, JAMES G., Dean of Engineering, Gonzaga University, Spokane, Wash. 1936
McGRADY, DENTON D., Assistant Professor of Chemical Engineering, Michigan State College, East Lansing, Mich. 1939
McGUIRE, JOHN G., Associate Professor of Engineering Drawing, A. & M. College of Texas, College Station, Texas 1939
McILROY, MALCOLM S., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1937
McINTYRE, HARRY J., Associate Professor of Mechanical Engineering, University of Washington, Seattle, Wash. 1939
McINTYRE, LEWIS W., Consulting Engineer, 6630 Woodwell St.; Lecturer, University of Pittsburgh, Pittsburgh, Pa. 1919
McKEE, EDD R., Professor and Head, Department of Electrical Engineering, University of Vermont, Burlington, Vt. 1934
McKEE, HARRY L., Supervisor, Evening Courses in Dept. of Shops, Carnegie Institute of Technology, Pittsburgh, Pa. 1938
McKEE, WAYNE S., Assistant Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1940
McKENRY, NELL, Assistant Secretary, Society for the Promotion of Engineering Education, University of Pittsburgh, Pittsburgh, Pa. *Assistant Secretary, 1918–* 1923
McKERGOW, C. M., Professor of Mechanical Engineering, McGill University, Montreal, Canada. (*Member of Council, 1927–30.*) 1913
McKIBBEN, EUGENE G., Professor and Head, Dept. of Agricultural Engineering, Michigan State College, East Lansing, Mich. 1937
McLAIN, STUART, Assistant Professor of Chemistry, University of Arkansas, Fayetteville, Ark. (Aberdeen Proving Grounds, Md.) 1936
McLAUGHLIN, D. H., Dean, College of Engineering, Professor and Chairman, Dept. of Mining Engineering, University of California, Berkeley, Calif. 1941
McLAUGHLIN, ROLAND R., Associate Professor of Chemical Engineering, University of Toronto, Toronto, Ont. 1940
McLAURIN, BANKS, Associate Professor of Civil Engineering, University of Texas, Austin, Texas 1927
McLEAN, WILLIAM G., Assistant Professor of Mechanical Engineering, Lafayette College, Easton, Pa. 1939
McMASTER, ALLEN S., Instructor in Electrical Engineering, University of Colorado, Boulder, Colo. 1931
McMASTER, ROBERT C., Teaching Fellow in Electrical Engineering, California Institute of Technology, Pasadena, Calif. 1939
McMILLAN, FRED O., Professor and Head, Dept. of Electrical Engineering, Oregon State College, Corvallis, Ore. 1932
McMILLEN, ELLIOTT L., Associate Professor and Head, Dept. of Chemical Engineering, Lafayette College, Easton, Pa. 1938
McMINN, BRYAN T., Professor of Mechanical Engineering, University of Washington, Seattle, Wash. 1939
McNAIR, ARTHUR J., Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1935
McNEARY, MATTHEW, Instructor in Engineering Drafting, University of Maine, Orono, Me. 1937
McNEILL, WALTER H., Professor and Chairman, Dept. of Drawing, University of Texas, Austin, Texas 1935
McNEW, JOHN T. L., Professor and Head, Dept. of Civil Engineering, A. & M. College of Texas, College Station, Texas 1937

MCNOWN, WILLIAM C., Professor and Head, Department of Civil Engineering, University of Kansas, Lawrence, Kansas 1935
MCREE, FITZHUGH L., Professor of Civil Engineering, Texas Technological College, Lubbock, Texas 1938
MEAD, DANIEL W., Professor Emeritus, Civil Engineering, University of Wisconsin, Madison, Wis. 1908
MEADE, KENNETH A., Director, Technical Employment, General Motors Corp., Detroit, Mich. 1940
MEADOWCROFT, NORMAN, Instructor in Aircraft Drafting and Detail Design, War Training Div., University of California, Los Angeles, Calif. 1942
MEARES, JEFFERSON S., Associate Professor of Physics, North Carolina State College, Raleigh, N. C. 1937
MEGEATH, SAMUEL A., Professor of Pre-Engineering, Spokane Junior College, Spokane, Wash. 1939
MEIKLE, G. STANLEY, Director, Research Relations with Industry, Purdue University, Lafayette, Ind. 1930
MEIKLEJOHN, ROBERT, Professor and Acting Chairman, Dept. of Engineering Drawing, The Ohio State University, Columbus, Ohio 1942
MEIXELL, L. GRANVILLE H., Engineering Librarian, Columbia University, New York City 1942
MELVIN, HAROLD W., Dean of Students, Professor of English, Northeastern University, Boston, Mass. 1932
MEMORY, NICHOL H., Director of Admissions, Stevens Institute of Technology, Hoboken, N. J. 1936
MERRIAM, KENNETH G., Professor of Aero Mechanics, Worcester Polytechnic Institute, Worcester, Mass. (*Life Member.*) **In military service** 1925
MERRICK, CHARLES M., Assistant in Industrial Eng. Dept., Glenn L. Martin Co., Baltimore, Md. 1929
MERRILL, DONALD W., Assistant Professor of Drawing and Architecture, University of Arkansas, Fayetteville, Ark. **In military service** ... 1939
MERRITT, CLARENCE W., Assistant Professor of Ceramic Engineering, New York State College of Ceramics, Alfred, N. Y. 1937
MERRITT, HAROLD W., Assistant Professor of Physics, Cooper Union, New York City 1927
MERRYFIELD, FRED, Associate Professor of Civil Engineering, Oregon State College, Corvallis, Ore. **In military service** 1938
MESERVE, GEORGE H., JR., Associate Professor of Drawing, Northeastern University, Boston, Mass. 1929
MESSERSMITH, CHARLES W., Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. **In military service** 1940
METCALF, ABBIE H., Librarian, Thayer School of Engineering, Dartmouth College, Hanover, N. H. 1942
METZENHEIM, HENRY H., Comptroller, Newark College of Engineering, Newark, N. J. 1926
MEYER, CARL F., Professor of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1937
MICKEY, CLARK E., Professor and Chairman, Dept. of Civil Engineering, University of Nebraska, Lincoln, Nebr. 1940
MIDDENDORF, HENRY Q., Assistant Professor of German, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. **In military service** 1940
MIDDLETON, EWEL V., Assistant Professor of Civil Engineering, Texas Technological College, Lubbock, Texas 1941

MIDGETTE, ERNST L., Associate Professor of Machine Design, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1940
MILES, ERNEST P., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. 1940
MILES, HENRY J., Associate Professor of Civil Engineering, University of Southern California, Los Angeles, Calif. 1938
MILES, JOHN C., Associate in Mechanical Engineering, University of Illinois, Urbana, Ill. 1939
MILGRAM, ARTHUR N., Instructor in Mathematics, University of Notre Dame, Notre Dame, Ind. 1939
MILLAR, A. V., Assistant Dean, Professor of Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. 1914
MILLARD, CLYDE I., Assistant Professor of Industrial Engineering, Cornell University, Ithaca, N. Y. 1938
MILLER, ALFRED L., Professor of Mechanics and Structures, University of Washington, Seattle, Wash. 1927
MILLER, CHARLES A., Assistant Professor of Civil Engineering, Michigan State College, East Lansing, Mich. 1937
MILLER, C. O., Assistant Professor of Chemical Engineering, Case School of Applied Science, Cleveland, Ohio 1939
MILLER, EDWARD C., Instructor in Metallurgical Engineering, Purdue University, Lafayette, Ind. **In military service** 1938
MILLER, F. CLIFFORD, Associate Professor of Engineering Drawing, Iowa State College, Ames, Iowa 1934
MILLER, FORREST E., Assistant Professor of Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. 1926
MILLER, FREDERIC H., Associate Professor of Mathematics, Cooper Union New York City 1941
MILLER, H. W., Professor of Mechanism and Engineering Drawing, University of Michigan, Ann Arbor, Mich. 1922
MILLER, JOHN B., Assistant Professor of Electrical Engineering, Bucknell University, Lewisburg, Pa. 1941
MILLER, JOSEPH, Assistant Professor of Industrial Management, Pratt Institute, Brooklyn, N. Y. 1942
MILLER, JOSEPH H., Associate Commissioner in charge of higher and professional education, State Education Dept., Albany, N. Y. 1941
MILLER, LORIN G., Professor and Head, Dept. of Mechanical Engineering, Michigan State College, East Lansing, Mich. 1937
MILLER, NATHAN, Associate Professor of Economics, Carnegie Institute of Technology, Pittsburgh, Pa. 1939
MILLER, WILLIAM B., Director and Instructor in Science, School of Science, Hyannis, Mass. 1941
MILLER, WILLIAM J., Professor and Head, Dept. of Electrical Engineering, University of Alabama, University, Ala. 1923
MILLER, WILLIAM T., Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1930
MILLIGAN, WILLIAM E., Assistant Professor of Metallurgy, Yale University, New Haven, Conn. 1933
MILLINGTON, HOWARD G., Assistant Professor of Mathematics, University of Vermont, Burlington, Vt. 1929
MILLMAN, JACOB, Assistant Professor of Electrical Engineering, College of the City of New York, New York City (on leave M. I. T.) 1942
MILLS, G. H., Assistant Professor of Electrical Engineering, Case School of Applied Science, Cleveland, Ohio 1926

MILLS, JOHN, Director of Publication, Bell Telephone Laboratories, Inc., 463 West St., New York City ... 1921
MINARIK, RUDOLPH G., Chief Designer, Kimberly-Clark Corp., Neenah, Wis. 1932
MINDLIN, RAYMOND D., Assistant Professor of Civil Engineering, Columbia University, New York City ... 1937
MINER, DOUGLAS F., George Westinghouse Professor of Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. **In military service** ... 1938
MING, FREDERICK W., Assistant Professor of Mechanical Engineering, Brooklyn Polytechnic Institute, Brooklyn, N. Y. ... 1918
MINKLER, HAROLD L., Instructor in Technical Drawing, Illinois Institute of Technology, Chicago, Ill. ... 1942
MINNICH, JOHN H., Assistant Professor of Civil Engineering, Thayer School of Engineering, Dartmouth College, Hanover, N. H. ... 1942
MINSHALL, ROBERT E., Professor of Structural Engineering, The Pennsylvania State College, State College, Pa. ... 1921
MIRABELLI, EUGENE, Associate Professor of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. ... 1935
MIRGAIN, FRANK C., Associate Professor of Civil Engineering, Rutgers University, New Brunswick, N. J. ... 1935
MITCHAM, JAMES T., Assistant Professor of Engineering and Trades, North Texas Agricultural College, Arlington, Texas ... 1941
MITCHELL, FRANCIS E., Instructor in Civil Engineering, University of Arkansas, Fayetteville, Ark. ... 1942
MITCHELL, LOUIS, Dean and Professor of Civil Engineering, Syracuse University, Syracuse, N. Y. (*Member of Council, 1938–41.*) ... 1913
MITCHELL, WILLIAM L., Dean of Men, Head, Dept. of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, La. ... 1939
MITSCH, JOHN D., Associate Professor of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. ... 1940
MOCK, CLIFTON O., Instructor in General Engineering, Purdue University, Lafayette, Ind. ... 1929
MOCKMORE, CHARLES A., Professor and Head, Dept. of Civil Engineering, Oregon State College, Corvallis, Ore. (*Member of Council, 1938–41.*) 1927
MOEN, WALTER B., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. ... 1941
MOENCH, HERMAN A., Assistant Professor of Electrical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. **In military service** 1934
MOFFAT, GEORGE N., Associate Professor of Mechanical Engineering, The Ohio State University, Columbus, Ohio ... 1925
MOGENSEN, A. H., Supervisor of Training Work Simplification, 330 West 42nd St., New York City ... 1941
MOHN, PAUL E., Associate Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. ... 1938
MOHR, JOHN G., Graduate Instructor in Glass Technology, New York State College of Ceramics, Alfred, N. Y. ... 1941
MOLSTAD, MELVIN C., Professor in Charge of Chemical Engineering, University of Pennsylvania, Philadelphia, Pa. ... 1937
MONTAGUE, EDWIN N., Principal Budget Examiner, Bureau of the Budget, Executive Offices of the President, Washington, D. C. **In military service** ... 1939
MONTILLON, GEORGE H., Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minn. ... 1925
MOODY, ARTHUR M. G., Research Engineer, De Laval Steam Turbine Co., Trenton, N. J. ... 1936

MOODY, HOWARD W., Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. 1938
MOODY, LEWIS F., Professor of Hydraulic Engineering, Princeton University, Princeton, N. J. 1912
MOORE, ARTHUR D., Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1926
MOORE, EARL R., Instructor in Mechanical Engineering, University of Connecticut, Storrs, Conn. 1930
MOORE, EMMETT B., Assistant Professor of Civil Engineering, State College of Washington, Pullman, Wash. 1936
MOORE, H. F., Research Professor of Engineering Materials, University of Illinois, Urbana, Ill. 1905
MOORE, MARK B., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. 1938
MOOSE, PERRY E., Assistant Professor of Engineering Drawing, North Carolina State College, Raleigh, N. C. **In military service** 1937
MORE, CHAS. C., Professor of Structural Engineering, University of Washington, Seattle, Wash. (*Member of Council, 1919–22.*) 1901
MOREHOUSE, J. STANLEY, Dean of Engineering, Professor of Mechanical Engineering, Villanova College, Villanova, Pa. 1935
MOREHOUSE, THEODORE C., Editor-in-Chief, College Dept., Macmillan Co., 60 5th Ave., New York City 1936
MORELAND, EDWARD L., Dean of Engineering, Massachusetts Institute of Technology, Cambridge, Mass. (*Vice President, 1940–41.*) 1934
MOREY, CHARLES W., President, Chicago Technical College, 2000 So. Michigan Ave., Chicago, Ill. 1925
MORGAN, JEROME J., Professor of Chemical Engineering, Columbia University, New York City 1925
MORGAN, JESSE R., Dean of the Faculty, Colorado School of Mines, Golden, Colo. 1927
MORGAN, JOHN C., Coördinator of Coöperative Work, Northeastern University, Boston, Mass. 1940
MORGAN, MILLETT G., Instructor in Power Engineering, Dartmouth College, Hanover, N. H. 1941
MORGAN, ROBERT B., Instructor in Electrical Engineering, Pratt Institute, Brooklyn, N. Y. 1942
MORGAN, STEWART S., Professor of English, A. & M. College of Texas, College Station, Texas 1938
MORGAN, THEODORE H., Professor and Head, Dept. of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. (*Member of Council, 1935–38.*) 1927
MORGEN, RALPH A., Professor of Chemical Engineering, University of Florida, Gainesville, Fla. 1938
MORLEY, RAYMOND K., Professor of Mathematics, Worcester Polytechnic Institute, Worcester, Mass. 1922
MORRIS, CLYDE T., Professor and Chairman, Dept. of Civil Engineering, The Ohio State University, Columbus, O. 1907
MORRIS, FREDERICK C., Instructor in Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1941
MORRIS, HAROLD, Instructor in Mechanical Engineering, Olinville Junior High School, Bronx, N. Y. 1941
MORRIS, HENRY M., Instructor in Civil Engineering, The Rice Institute, Houston, Texas 1942
MORRIS, SAMUEL B., Dean, Professor of Civil Engineering, Stanford University, Stanford University, Calif. 1935

MORRISON, EDMUND, Assistant Professor of English, University of British Columbia, Vancouver, B. C. 1940
MORRISON, ROGER L., Professor of Highway Engineering and Highway Transport, University of Michigan, Ann Arbor, Mich. 1925
MORSE, FREDERICK T., Associate Professor of Mechanical Engineering, University of Virginia, University, Va. 1927
MORSE, JAMES L., Mechanical and Structural Engineer, U. S. Bureau of Reclamation, 1210 Ogden St., Denver, Colo. 1910
MORSE, REED F., Associate Professor of Civil Engineering, Kansas State College, Manhattan, Kansas 1929
MORTON, P. L., Instructor in Electrical Engineering, University of California, Berkeley, Calif. 1939
MORTON, ROSCOE W., Professor and Head, Dept. of Mechanical Engineering, University of Tennessee, Knoxville, Tenn. (*Member of Council, 1936–39.*) 1929
MOSER, KENNETH J., Assistant Professor of Mechanical Engineering, Villanova College, Villanova, Pa. 1936
MOSHER, S. W., Chief Engineer, Municipal Civil Service Commission, 117–27 231 St., Saint-Albans, L. I., N. Y. 1939
MOSS, HELEN J., Librarian, Engineering Library, Yale University, New Haven, Conn. 1941
MOTA, CALOR C., Professor and Head, Dept. of Civil Engineering, University of Porto Rico, Mayaguez, P. R. 1925
MOTT, WILLIAM E., Director Emeritus, Carnegie Institute of Technology, 315 Wood St., Burlington, N. J. (*Member of Council, 1917–20.*) .. 1907
MOULTON, REXFORD G., Assistant Professor of Mechanical Engineering, University of Toledo, Toledo, Ohio 1941
MOWBRAY, WILLIAM J., Instructor in Electrical Engineering and Engineering Drawing, Rhode Island State College, Kingston, R. I. 1935
MOYER, JAMES A., Director, Division of University Extension, Massachusetts Department of Education, Boston, Mass. 1904
MOYER, RALPH A., Research Associate Professor of Civil Engineering, Iowa State College, Ames, Iowa 1929
MOYNIHAN, JOHN R., Associate Professor of Experimental Mechanical Engineering, Cornell University, Ithaca, N. Y. 1939
MUCKENHOUPT, CARL F., Professor and Head, Department of Physics, Northeastern University, Boston, Mass. 1937
MUELLER, GEORGE V., Associate Professor of Electrical Engineering, Purdue University, Lafayette; Ind. 1926
MUIR, ROY C., Vice President in Charge of Engineering, General Electric Co., Schenectady, N. Y. 1940
MULLINS, B. F. K., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas 1938
MUMFORD, CAREY G., Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1937
MUNDEL, MARVIN E., Assistant Professor of General Engineering, Bradley Polytechnic Institute, Peoria, Ill. 1941
MUNDT, AUGUST J., Personnel Director of Engineering, Western Union Telegraph Co., 60 Hudson St., New York City 1942
MUNRO, GEORGE W., Professor of Thermodynamics, Retired, Purdue University, Lafayette, Ind. 1915
MUNSON, THURMOND A., Professor of Hydraulic Engineering, A. & M. College of Texas, College Station, Texas 1938
MURDICHIAN, KARMY, Instructor in Civil Engineering, Virginia Polytechnic Institute, Norfolk, Va. 1942

MURDOUGH, J. H., Professor and Head, Dept. of Civil Engineering, Texas Technological College, Lubbock, Texas 1926
MURPHY, EUGENE F., Instructor in Mechanical Engineering, University of California, Berkeley, Calif. 1939
MURPHY, GLENN, Professor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa 1929
MURPHY, LINDON J., Associate Professor (Municipal Engineer) Engineering Extension Service, Iowa State College, Ames, Iowa 1930
MURPHY, NELSON F., Assistant Professor of Chemical Engineering, Syracuse University, Syracuse, N. Y. 1941
MURRAY, RAY M., 1638 Interlaken Blvd., Seattle, Wash. 1940
MURRAY, WILLIAM A., Professor and Head, Dept. of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1935
MYERS, FRANK E., Assistant Professor of Physics, New York University, New York City. **In military service** 1938
MYERS, HOWARD D., Associate Professor of Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. 1922
MYKLESTAD, NILS O., Assistant Professor of Machine Design, Illinois Institute of Technology, Chicago, Ill. **In military service** 1939
MYLREA, THOMAS D., Professor and Head, Division of Civil Engineering, University of Delaware, Newark, Del. 1935
NACHMAN, HENRY L., Professor of Thermodynamics, Illinois Institute of Technology, Chicago, Ill. 1941
NAETER, ALBRECHT, Professor and Head, Department of Electrical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1924
NAHIKIAN, HOWARD M., Assistant Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1937
NARMORE, PHIL B., Assistant to the Dean, Professor of Engineering Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. 1934
NASH, C. A., Associate Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1913
NASH, PHILLIP C., President, University of Toledo, Toledo, Ohio 1921
NASH, THOMAS L., Lt. Comdr. U. S. Navy, Bureau of Ships, Washington, D. C. 1938
NEAL, HENRY P., Associate Professor of Engineering Drawing, Mississippi State College, State College, Miss. 1941
NEEDHAM, C. E., President, New Mexico School of Mines, Socorro, N. M. 1941
NEEDY, JOHN A., Dean of Engineering, Ohio Northern University, Ada, Ohio 1919
NELSON, ALFRED L., Professor and Head, Dept. of Mathematics, Wayne University, Detroit, Mich. 1939
NELSON, DELMAR W., Associate Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. 1929
NELSON, ERIC W., Assistant Professor of Mechanical Engineering, Lafayette College, Easton, Pa. 1939
NELSON, PAUL H., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. 1942
NELSON, WILBUR L., Professor and Head, Dept. of Chemical and Petroleum Refinery Engineering, University of Tulsa, Tulsa, Okla. 1941
NESBITT, RICHARD E., Instructor in Foundry Practice and Mechanical Technology, Pratt Institute, Brooklyn, N. Y. 1930
NETHKEN, HARLEY J., Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. 1939

NETTLETON, E. B., Associate Professor of Drawing and Descriptive Geometry, Carnegie Institute of Technology, Pittsburgh, Pa. 1937
NEUGEBAUER, GEORGE H., Assistant Professor of Machine Design, Cooper Union, New York City 1938
NEWELL, HOBART H., Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1925
NEWMAN, ALBERT B., Dean, School of Technology, College of the City of New York, New York City 1929
NEWMAN, C. M., Professor of English, Virginia Polytechnic Institute, Blacksburg, Va. 1917
NEWMAN, MARCEL K., Instructor in Mechanics, Columbia University, New York City 1937
NEWTON, DUDLEY, Associate Professor and Head, Dept. of Civil Engineering, Wayne University, Detroit, Mich. 1938
NICHOLS, BEN H., Associate Professor of Electrical Engineering, Oregon State College, Corvallis, Ore. **In military service** 1930
NICHOLS, CLYDE R., Dean of Engineering, Arkansas Polytechnic Institute, Russellville, Ark. **In military service** 1936
NICHOLSON, HUGH P., Assistant Professor of Mining Engineering, University of Illinois, Urbana, Ill. 1940
NICHOLSON, NATALIE N., Librarian, Graduate School of Engineering, Harvard University, Cambridge, Mass. 1941
NICKELSEN, JOHN M., Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1940
NICKOLLS, CHARLES L., Professor of Chemical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
NIGHTINGALE, WINTHROP E., Director of Coöperative Work and Professor of Coordination, Northeastern University, Boston, Mass. 1925
NILES, ALFRED S., Professor of Aeronautical Engineering, Stanford University, Stanford University, Calif. 1940
NILSON, ARTHUR R., President and Chief Instructor, Nilson Radio School, 51 East 42nd St., New York City 1942
NIMS, ALBERT A., Professor of Electrical Engineering, Newark College of Engineering, Newark, N. J. 1928
NOBLE, GILBERT W., Associate Professor of Petroleum Engineering, Missouri School of Mines & Metallurgy, Rolla, Mo. 1940
NOLD, HARRY E., Professor and Chairman, Dept. of Mine Engineering, The Ohio State University, Columbus, Ohio 1937
NOLLAU, LOUIS E., Professor and Head, Department of Drawing, University of Kentucky, Lexington, Ky. 1928
NORDENHOLT, GEORGE F., Editor, *Product Engineering*, McGraw-Hill Publishing Co., 330 West 42nd St., New York, N. Y. 1931
NORDLING, CARL G. A., Instructor in Mathematics, University of Connecticut, Storrs, Conn. 1942
NORMAN, CARL A., Professor of Machine Design, The Ohio State University, Columbus, O. 1918
NORMAND, HAL C., Instructor in Civil Engineering, Texas Technological Institute, Lubbock, Texas 1938
NORRIS, CARROL B., Assistant Professor of Electrical Engineering, Tulane University, New Orleans, La. 1937
NORRIS, EARLE B., Dean of Engineering, Virginia Polytechnic Institute, Blacksburg, Va. (*Member of Council, 1924–7.*) 1907
NORRIS, FERRIS W., Associate Professor of Electrical Engineering, University of Nebraska, Lincoln, Nebr. 1925

NORTHCOTT, JOHN A., JR., Professor of Electrical Engineering, University of Notre Dame, Notre Dame, Ind. 1938

NORTHRUP, RALPH T., Head, Dept. of Engineering Drawing, Wayne University, Detroit, Mich. 1934

NORTON, FREDERICK H., Associate Professor of Ceramics, Massachusetts Institute of Technology, Cambridge, Mass. 1937

NORTON, PAUL T., JR., Professor and Head, Dept. of Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. (*Member of Council, 1934–37.*) 1926

NORWOOD, JOHN N., President, Alfred University and New York State College of Ceramics, Alfred, N. Y. 1941

NOTHSTINE, LEO V., Instructor in Civil Engineering, Texas Technological College, Lubbock, Texas 1940

NOWICKI, ALBERT L., Assistant Professor of Civil Engineering, Marquette University, Milwaukee, Wis. **In military service** 1938

NUDD, PHILIP, Assistant Professor of Electrical Engineering, Cooper Union, New York City 1939

NUDD, WILLARD E., Registrar; Associate Professor of Engineering Drawing, Case School of Applied Science, Cleveland, O. 1923

NUGENT, HOMER H., Professor and Head, Dept. of English, Rensselaer Polytechnic Institute, Troy, N. Y. 1937

NULSEN, WILLIAM B., Assistant Professor of Electrical Engineering, University of New Hampshire, Durham, N. H. 1936

NUNAN, JAMES K., Assistant Professor of Electrical Engineering, Assistant to the Dean of Engineering, University of Southern California, Los Angeles, Calif. 1940

NYE, EDWIN P., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. 1942

NYLAND, WAINO, Associate Professor of English, University of Colorado, Boulder, Colo. 1936

OAKEY, JOHN A., Associate Professor and Head, Dept. of Civil Engineering, Villanova College, Villanova, Pa. 1936

OBERG, AARON G., Assistant Professor of Chemical Engineering, Texas Technological College, Lubbock, Texas 1941

OBERT, EDWARD F., Assistant Professor of Mechanical Engineering, Northwestern Technological Institute, Evanston, Ill. 1940

O'BRIEN, A. V., Superintendent, Manufacturers Laboratory, Instructor of Mechanical Engineering, State University of Iowa, Iowa City, Iowa 1923

O'BRIEN, ELWIN J., Associate Professor of Electrical Engineering, University of North Dakota, Grand Forks, N. D. 1938

O'BRIEN, EUGENE W., Vice President, W. R. C. Smith Pub. Co., Managing Director, Southern Power & Industry, Atlanta, Ga. 1935

O'BRIEN, MORROUGH P., Professor and Chairman, Dept. of Mechanical Engineering, University of California, Berkeley, Calif. 1939

OCKERBLAD, ANDREW M., Associate Professor of Applied Mechanics, University of Kansas, Lawrence, Kansas 1935

O'CONNELL, DANIEL J., Associate Professor of Civil Engineering, Manhattan College, New York, N. Y. 1931

O'CONNOR, GUSTAVUS R., Commander, United States Coast Guard Academy, New London, Conn. 1941

O'CONNOR, JOHNSON, Director, Human Engineering Laboratory, Stevens Institute of Technology, Hoboken, N. J. 1931

OCVIRK, FRED W., Instructor in Mechanics, Cornell University, Buffalo, N. Y. 1942
ODEN, E. CLARENCE, Assistant Professor of Chemical Engineering, Michigan State College, East Lansing, Mich. 1941
O'DONNELL, R. O., Professor of Hydraulics and Sanitary Engineering, The Pennsylvania State College, State College, Pa. 1934
OESTERLE, JOSEPH F., Chairman, Dept. of Mining and Metallurgical Engineering, University of Wisconsin, Madison, Wis. 1935
O'FARRELL, JOHN B., Technology Librarian, College of the City of New York, New York City 1941
OGBURN, S. CICERO, JR., Technical Supervisor, General Chemical Co., 40 Rector St., New York City. (*Member of Council, 1935–8.*) 1928
OLDENBURGER, RUFUS, Professor of Mathematics, Illinois Institute of Technology, Chicago, Ill. 1942
O'LEARY, ALLAN M., Instructor in General Engineering and Mathematics, University of Dayton, Dayton, Ohio 1941
OLER, CHARLES B., Instructor in Engineering, Swarthmore College, Swarthmore, Pa. 1941
OLESON, CALVIN C., Acting Head, Associate Professor of Civil Engineering, South Dakota State College, Brookings, S. D. 1938
OLIN, HUBERT L., Professor of Chemical Engineering, State University of Iowa, Iowa City, Iowa 1936
OLIVER, JOHN C., Registrar, Association of Professional Engineers, Vancouver, B. C., Canada. **In military service** 1938
OLIVER, WILLIAM A., Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1928
OLMSTED, CHARLES T., Associate Professor of Engineering Mechanics, Assistant Dean of Students, University of Michigan, Ann Arbor, Mich. 1929
OLSEN, GERNER A., Assistant Professor of Civil Engineering, Rutgers University, New Brunswick, N. J. 1936
OLSEN, JOHN C., Professor of Chemical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1930
OLSEN, LEROY, Instructor in Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1940
OLSON, OSCAR A., Professor and Head, Dept. of Engineering Drawing, Iowa State College, Ames, Ia. 1915
O'MEARS, THOMAS J., Instructor in Electrical Engineering, Manhattan College, New York City 1941
OPDYKE, JOHN B., Engineer, Lago Oil and Transport Co., Ltd., Aruba, Curaco 1937
ORMONDROYD, JESSE, Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. 1939
O'ROURKE, CHARLES E., Professor of Structural Engineering, Cornell University, Ithaca, N. Y. 1941
O'ROURKE, FRANK J., Instructor in Sheet Metal, Quincy Trade School, 35 Pontiac St., Quincy, Mass. 1942
ORTH, HERBERT D., Professor and Head, Dept. of Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. 1910
OSBORN, FRANCIS C., Head, Industrial Arts Dept., Chairman of Engineering Curriculum, Arizona State Teachers College, Flagstaff, Ariz. 1934
OSBORN, JOHN R., Instructor in Civil Engineering, A. & M. College of Texas, College Station, Texas 1940
OSBORNE, HAROLD S., Assistant Chief Engineer, American Tel. & Tel. Co., 195 Broadway, New York City 1935

OSBORNE, SHERIDAN, Instructor in Engineering Drawing, Wayne University, Detroit, Mich. 1940
OSBURN, ORREN E., Assistant Professor of Electrical Engineering, Washington State College, Pullman, Wash. 1932
O'SHAUGHNESSY, LOUIS, Professor and Head, Dept. of Applied Mechanics, Director of Graduate Studies, Virginia Polytechnic Institute, Blacksburg, Va. 1912
OSTERHOF, GERARD G., Professor and Head, Dept. of Chemistry, South Dakota State School of Mines, Rapid City, S. D. 1940
OSTROM, CHARLES D. V., Instructor in Civil Engineering, University of California; 3024 Clay St., San Francisco, Calif. **In military service** 1939
OSWALD, CHARLES T., Chairman of Engineering, Scranton-Keystone Junior College, La Plume, Pa. 1942
OTHMER, DONALD F., Professor and Head, Dept. of Chemical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1937
OTHMER, MURRAY E., Associate Professor of Chemical Engineering, Tufts College, Medford, Mass. 1942
OTHUS, JAMES C., Associate Professor of Mechanical Engineering, Oregon State College, Corvallis, Ore. 1928
OTT, PERCY W., Professor and Chairman, Dept. of Mechanics, The Ohio State University, Columbus, Ohio 1925
OTTER, JOHN V., Project Manager, Naval Ordnance Plant, MK Co., Pocatello, Idaho 1929
OTTO, LOUIS L., Instructor in Experimental Engineering, Cornell University, Ithaca, N. Y. 1941
OVERCASH, RAY L., Instructor in Chemical Engineering, North Carolina State College, Raleigh, N. C. 1942
OWEN, HALSEY F., Associate Professor of Industrial Engineering, Purdue University, Lafayette, Ind. 1940
OWEN, RAY S., Associate Professor of Topographical Engineering, University of Wisconsin, Madison, Wis. 1937
OWENS, FREDERICK W., Professor and Head, Dept. of Mathematics, The Pennsylvania State College, State College, Pa. 1926
PADDOCK, RUSSELL G., Professor and Head, Dept. of Mechanical Engineering, University of Arkansas, Fayetteville, Ark. 1931
PAFFENBARGER, RALPH S., Professor of Engineering Drawing, The Ohio State University, Columbus, Ohio 1932
PAINE, ELLERY B., Professor and Head, Dept. of Electrical Engineering, University of Illinois, Urbana, Ill. 1911
PAINTER, ROBERT J., Assistant to the Secretary, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. 1941
PALMER, DELOS M., Dean of Engineering, University of Toledo, Toledo, Ohio 1933
PALMER, HARLAN B., Professor of Electrical Engineering, University of Colorado, Boulder, Colo. 1939
PALMER, HERALD K., Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. 1930
PALMER, STANLEY G., Professor and Head, Dept. of Electrical Engineering, Dean, University of Nevada, Reno, Nev. 1937
PALMERTON, LEIGHTON R., Director of Student Personnel, Associate Professor of Social Science, South Dakota State School of Mines, Rapid City, S. D. 1940
PALSGROVE, GRANT K., Professor of Hydraulic Engineering, Secretary to Faculty, Rensselaer Polytechnic Institute, Troy, N. Y. 1918

PANUSKA, FRANK C., Administrative Assistant, Stuyvesant High School, New York City 1937
PARK, C. F., Professor Emeritus, Director of Lowell Institute School, Massachusetts Institute of Technology, Cambridge, Mass. 1903
PARK, C. W., Professor of English, College of Engineering and Commerce, University of Cincinnati, Cincinnati, O. (*Member of Council, 1932–35.*) 1915
PARK, H. V., Assistant Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1938
PARK, JOHN C., Professor of Highway Engineering, University of Arizona, Tucson, Ariz. 1931
PARKER, ERI B., Associate Professor of Mechanical Engineering, State College of Washington, Pullman, Wash. 1926
PARKER, J. C., Vice President Consolidated Edison Co. of New York, 4 Irving Place, New York City 1916
PARKER, JOHN M., Assistant Professor of Geology, North Carolina State College, Raleigh, N. C. 1939
PARKER, NORMAN A., Professor and Head, Dept. of Mechanical Engineering, University of Colorado, Boulder, Colo. 1941
PARKER, WALTER H., Professor of Mining, University of Minnesota, Minneapolis, Minn. 1925
PARKHILL, GORDON W., Civil Engineer, 702 Main St., Lubbock, Texas .. 1938
PARKINSON, LESLIE R., Head, Dept. of Aeronautical Engineering, North Carolina State College, Raleigh, N. C. **In military service** 1937
PARKS, WILBUR H., Instructor in Mechanical Engineering, University of Denver, Denver, Colo. 1942
PARR, JOHNSTONE, Director of Engineering English, University of Alabama, Tuscaloosa, Ala. 1941
PARROTT, ALICE A., Head, Department of English, Tri-State College, Angola, Ind. 1932
PARSONS, ARTHUR B., Secretary, American Institute of Mining & Metallurgical Engineers, 33 West 39th Street, New York City 1939
PARSONS, H. MERLE, Secretary and Registrar, South Dakota State School of Mines, Rapid City, S. D. 1940
PARTLO, F. L., Associate Professor of Mathematics and Physics, Michigan College of M. & T., Houghton, Mich. 1939
PATTEN, LAWTON M., Instructor in Engineering Drawing, New York University, New York City 1938
PATTEN, W. E., Assistant Hydraulic Engineer Flood Control Survey, U. S. Dept. Agriculture, Upper Darby, Pa.; 1306 Irish St., So. Boston, Va. 1915
PATTERSON, GEORGE R., Assistant Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1937
PATTERSON, L. L., Dean of Engineering, Professor of Electrical Engineering, Mississippi State College, State College, Miss. 1915
PATTERSON, ROBERT A., Professor and Head, Dept. of Physics, Rensselaer Polytechnic Institute, Troy, N. Y. 1937
PATTERSON, STANLEY, Instructor in Mechanical Engineering, Southern Methodist University, Dallas, Texas 1940
PATTISON, FLOYD, Professor of Mechanical Engineering, Extension Division, Kansas State College, Manhattan, Kansas 1934
PAUL, C. E., Professor Emeritus of Mechanics, Illinois Institute of Technology, Chicago, Ill. 1907
PAULSEN, FRIDTJOF, Instructor in Mathematics and Engineering, San Mateo Junior College, San Mateo, Calif. 1935

PAUSTIAN, JOHN, Instructor in Mechanics, University of Nebraska, Lincoln, Nebr. 1941
PAUSTIAN, RAYMOND G., Assistant Professor of Civil Engineering, Iowa State College, Ames, Iowa 1930
PAVIAN, HENRY C., Assistant Professor of Aeronautical Engineering, University of Pittsburgh, Pittsburgh, Pa. **In military service** 1935
PAYNE, WILLIAM M., Instructor in Mechanical Engineering, New York University, New York, N. Y. 1941
PAYROW, HARRY G., Associate Professor of Sanitary Engineering, Lehigh University, Bethlehem, Pa. 1930
PEARCE, CLINTON E., Professor and Head, Dept. of Machine Design, Kansas State College, Manhattan, Kansas 1937
PEARCE, F. W., Assistant Professor of General Engineering, Northern Montana College, Havre, Mont. 1938
PEARL, WILLIAM A., Vice President in charge of Manufacturing, Whiting Corp., Chicago, Ill. 1935
PEARSON, DONALD S., Professor and Head, Dept. of Electrical Engineering, Ohio Northern University, Ada, Ohio 1939
PEARSON, JOHN E., Instructor in General Engineering Drawing, University of Illinois, Urbana, Ill. **In military service** 1942
PEASE, ED. M. J., Associate Professor of Mathematics and Electrical Engineering, Rhode Island State College, Kingston, R. I. 1937
PECK, JOHN S., Assistant Professor of Civil Engineering, College of City of New York, New York, N. Y. 1931
PECK, RALPH E., Assistant Professor of Chemical Engineering, Illinois Institute of Technology, Chicago, Ill. 1941
PEEBLES, JAMES C., Dean of Engineering, Illinois Institute of Technology, Chicago, Ill. 1927
PEERY, DAVID J., Assistant Professor of Aeronautical Engineering, The Pennsylvania State College, State College, Pa. 1938
PEET, J. C., Professor of Electrical Engineering, Newark College of Engineering, Newark, N. J. 1923
PEGRAM, GEORGE B., Professor of Physics, Dean of Graduate Faculties, Columbia University, New York, N. Y. (*President, 1925–6; Vice President, 1924–5; Member of Council, 1924–.*) 1918
PEIRCE, GEORGE R., Instructor in Electrical Engineering, University of Illinois, Urbana, Ill. 1939
PENCE, W. D., Consulting Engineer, Room 1947, 120 South La Salle Street, Chicago, Ill. 1895
PENDER, HAROLD, Dean, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. (*Member of Council, 1924–7.*) 1909
PENDRAY, G. EDWARD, Assistant to President, Westinghouse E. & M. Co., Pittsburgh, Pa. 1942
PENN, JOHN C., Professor of Civil Engineering, Illinois Institute of Technology, Chicago, Ill. 1915
PENNOCK, OLIVER P., Associate Professor of Civil Engineering, Colorado State College, Ft. Collins, Colo. 1939
PEREZ, LAWRENCE, Assistant Professor of Civil Engineering, Cooper Union, New York City 1933
PERKINS, DONALD L., Professor and Head, Dept. of Mechanical Engineering, Wayne University, Detroit, Mich. 1930
PERKINS, HAROLD C., Assistant Professor of Mechanics, Cornell University, Ithaca, N. Y. 1934

PERRY, JOHN E., Assistant Professor of Railroad Engineering, Cornell University, Ithaca, N. Y. 1922
PERRY, JOHN H., Technical Investigator, du Pont de Nemours & Co., Wilmington, Del. 1939
PERRY, LYNN, Associate Professor of Civil Engineering, Lafayette College, Easton, Pa. 1923
PERRY, ROBERT V., Professor of Machine Design, Illinois Institute of Technology, Chicago, Ill. 1926
PERRYMAN, CONNER C., Associate Professor of Engineering Drawing, Texas Technological College, Lubbock, Texas 1938
PERSON, H. T., Professor and Chairman, Dept. of Civil Engineering, University of Wyoming, Laramie, Wyo. 1932
PETERS, ARTHUR S., Instructor in Mathematics, New York University, New York City 1938
PETERSON, ALDOR C., Instructor in Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa 1939
PETERSON, ANDREW I., Associate Professor of Engineering Economics, New York University, New York City 1933
PETERSON, ERNEST F., Professor of Electrical Engineering, University of Santa Clara, Santa Clara, Calif. 1936
PETERSON, F. G. ERIC, Assistant Professor of General Engineering, Montana State College, Bozeman Mont. 1929
PETRIE, GEORGE W., Lt. (jg) Instructor, USNR Midshipmen's School, New York City 1938
PETRIE, JOHN M., Assistant Professor of Chemical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1937
PETTIT, JOSEPH M., Instructor in Electrical Engineering, University of California, Berkeley, Calif. (Harvard University, Cambridge, Mass.) 1940
PETTY, BENJAMIN H., Professor of Highway Engineering, Purdue University, Lafayette, Ind. 1925
PETTYJOHN, ELMORE S., Associate Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich. **In military service** .. 1939
PEURIFOY, ROBERT L., Director, Division of Engineering, Professor of Civil Engineering, Texas College of Arts and Industries, Kingsville, Texas; Field Rep. ESMDT, U. S. Office of Education, Washington, D. C. 1931
PHELEY, DONAL B., Instructor in Physics and Astronomy, Los Angeles City College, Los Angeles, Calif. 1933
PHELPS, CHARLES W., Instructor in Mechanical Engineering, Yale University, New Haven Conn. 1936
PHELPS, GEORGE O., Associate Professor of Mechanical Engineering, Mississippi State College, State College, Miss. 1937
PHELPS, GUY M., Professor and Head, Dept. of Drawing, Rensselaer Polytechnic Institute, Troy, N. Y. 1925
PHELPS, J. M., Admissions Counselor, Rose Polytechnic Institute, Terre Haute, Ind. 1941
PHILBRICK, HERBERT S., Professor of Mechanical Engineering, Northwestern University, Evanston, Ill. 1913
PHILBY, ALFRED J., Assistant Professor of Engineering Drawing, The Ohio State University, Columbus, Ohio 1942
PHILLIPS, ARTHUR, Professor of Metallurgy, Yale University, New Haven, Conn. 1937
PHILLIPS, E. J., Assistant Professor of Structural Engineering, Fenn College, Cleveland, Ohio 1941

PHILLIPS, HENRY B., Professor and Head, Dept. of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. 1935
PHILLIPS, JOHN B., Associate Professor of Chemical Engineering, McGill University, 4345 Harvard Avenue, Montreal, Canada 1931
PICKARD, WILLIS L., Instructor in Mathematics, North Texas Agricultural College, Arlington, Texas 1940
PICKELS, GEORGE W., Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1932
PIERCE, CLARENCE A., Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1925
PIERCE, STANLEY H., Associate in General Engineering Drawing, University of Illinois, Urbana, Ill. 1937
PIERSON, WARNER N., Instructor in Chemical Engineering, University of Detroit, Detroit, Mich. 1942
PIETENPOL, CLARENCE J., Dean of Engineering, Washington and Jefferson College, Washington, Pa. 1942
PIETENPOL, WILLIAM B., Professor and Head, Dept. of Physics, University of Colorado, Boulder, Colo. 1942
PIGAGE, LEO O., Instructor in General Engineering, Purdue University, Lafayette, Ind. 1939
PILLET, F. F., Professor of Civil Engineering, Louisiana State University, University, La. 1935
PINSKY, JOSEPH, Associate Professor of Mechanical Engineering, Colorado State College, Fort Collins, Colo. 1939
PIPER, FRED F., Professor of Physics, Clarkson College of Technology, Potsdam, N. Y. 1915
PIRCHIO, PASQUALE M., Professor and Head, Dept. of Engineering Drawing, University of Notre Dame, Notre Dame, Ind. 1938
PITTS, ROBERT G., Professor of Aeronautical Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1938
PLANK, WILLIAM B., Head, Dept. of Mining Engineering and Metallurgy, Lafayette College, Easton, Pa. (*Member of Council, 1938–41.*) 1921
PLANT, L. C., Professor and Head of the Department of Mathematics, Michigan State College, East Lansing, Mich. 1913
PLETTA, DAN H., Professor of Applied Mechanics, Virginia Polytechnic Institute, Blacksburg, Va. **In military service** 1932
PLOCK, HENRY, Instructor in Drafting, College of the City of New York, New York City 1940
PLOWMAN, ASHLEY S., Professor and Head, Department of Electrical Engineering and Physics, Newcastle Technical College, Newcastle, N.S.W., Australia 1937
PLUMMER, CLAYTON R., Instructor in Mechanical Drawing and Machine Design, University of Tennessee, Knoxville, Tenn. 1941
PLUMMER, FRED L., Chief Research Engineer, Hammond Iron Works, Warren, Pa. 1930
POLANER, JEROME L., Instructor in Mechanical Engineering, Newark College of Engineering, Newark, N. J. 1941
POLKINGHORNE, WILFRID C., Associate Professor of Civil Engineering, Michigan College of M. & T., Houghton, Mich. 1939
POLLARD, JAMES J., Instructor in Drawing and General Engineering, Tulane University, New Orleans, La. 1941
POMEROY, GEORGE A., Head, Dept. of Physical Science, San Mateo Junior College, San Mateo, Calif. 1941
POOLE, FRED L., Professor of Electrical Engineering, Gonzaga University, Spokane, Wash. 1929

POOLE, HAROLD M., Assistant Professor of Industrial Engineering, The Ohio State University, Columbus, Ohio. **In military service** 1940
POORMAN, A. P., Professor of Applied Mechanics, Purdue University, Lafayette, Ind. (*Member of Council, 1932–35.*) 1907
POPE, LATHROP C., Instructor in Civil Engineering, College of the City of New York, New York City 1937
PORSCH, JOHN H., Associate Professor of Engineering Drawing, Purdue University, Lafayette, Ind. 1929
PORTER, DAVID B., Professor of Industrial Engineering, New York University, New York City 1923
PORTER, DAVID J., Assistant Professor of Chemical Engineering, University of Missouri, Columbia, Mo. 1939
PORTER, FRANCIS M., Associate Professor of General Engineering Drawing, University of Illinois, Urbana, Ill. 1912
PORTER, GEORGE M., Associate Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1941
PORTER, L. MORGAN, Engine Designer, Pratt & Whitney Div., United Aircraft Corp., East Hartford, Conn. 1937
PORTER, R. A., Professor of Physics, Syracuse University, Syracuse, N. Y. 1908
PORTER, R. CLAY, Assistant Professor of Heat Power Engineering, University of Michigan, Ann Arbor, Mich. 1935
PORTER, ROLAND G., Professor and Head, Department of Electrical Engineering, Northeastern University, Boston, Mass. 1926
POSEY, CHESLEY J., Associate Professor of Hydraulics and Structural Engineering, State University of Iowa, Iowa City, Iowa 1931
POTTER, ANDREY A., Dean, Schools of Engineering, Director Engineering Experiment Station, Purdue University, Lafayette, Ind. (*President, 1924-5; Vice President, 1919–20; Member of Council, 1916–19; 1924–.*) **Thirteenth Recipient, Lamme Medal (1940)** 1908
POTTER, JAMES G., Professor of Physics and Administrator of General Engineering, South Dakota School of Mines, Rapid City, S. D. 1935
POTTER, JAMES H., Instructor in Mechanical Engineering, The Johns Hopkins University, Baltimore, Md. 1941
POTTER, JAMES L., Associate Professor of Electrical Engineering Rutgers University, New Brunswick, N. J. 1936
POTTER, ORRIN W., Assistant Professor of Engineering Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. .. 1925
POTTER, PHILIP J., Instructor in Mechanical Engineering, Swarthmore College, Swarthmore, Pa. 1942
POWELL, ALBERT P., Assistant Professor of Electrical Engineering, The Pennsylvania State College, State College, Pa. 1926
POWELL, RALPH W., Associate Professor of Mechanics, The Ohio State University, Columbus, Ohio 1922
POWER, HARRY H., Professor and Chairman, Dept. of Petroleum Engineering, University of Texas, Austin, Texas 1938
POWERS, A. RAYMOND, Professor of Electrical Engineering, Clarkson College of Technology, Potsdam, N. Y. 1941
PRAEGER, EMIL, Professor and Head, Dept. of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1939
PRAGEMAN, IRVING H., Associate Professor of Mechanical Engineering, University of Maine, Orono, Maine 1923
PRATT, CHARLES, Secretary, Board of Trustees, Pratt Institute, Brooklyn, N. Y. 1929
PRATT, GROVER M., Assistant Professor of Drawing and Design, Michigan State College, East Lansing, Mich. 1935

PRENTICE, DONALD B., President, Rose Polytechnic Institute, Terre Haute, Ind. (*President, 1940–41; Vice President, 1939–40; Member of Council, 1927–30, 1939–.*) 1912
PRENTICE, THOMAS H., Assistant Professor of Civil Engineering, College of the City of New York, New York City 1936
PRESCOTT, SAMUEL C., Professor Emeritus and Honorary Lecturer, Massachusetts Institute of Technology, Cambridge, Mass. 1940
PRESTON, HOWARD K., Professor and Head, Dept. of Mechanics, University of Delaware, Newark, Del. 1942
PRIAN, VASILY D., Acting Head, Dept. of Mechanical Engineering, Fenn College, Cleveland, Ohio 1936
PRICE, HAROLD W., Professor of Electrical Engineering, University of Toronto, Toronto, Ont., Canada 1924
PRICE, JOHN R., Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1926
PRICE, LEONARD C., Associate Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. 1931
PRICE, ROBERT, Instructor in English, The Ohio State University, Columbus, Ohio 1942
PRIDE, H. HAMMOND, Professor of Mathematics, New York University, New York City 1938
PRIEN, CHARLES H., Instructor in Chemical Engineering, University of Colorado, Boulder, Colo. 1941
PRIESTER, GAYLE B., Instructor in Mechanical Engineering, Case School of Applied Science, Cleveland, Ohio 1941
PRIESTER, GEORGE C., Professor and Acting Head, Dept. of Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. 1920
PRIOR, JOHN A., Assistant Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1923
PRIOR, JOHN C., Professor of Civil and Sanitary Engineering, The Ohio State University, Columbus, Ohio 1926
PRIOR, THOBURN W., Personnel Dept., Goodyear Tire and Rubber Co., Akron, Ohio 1937
PUCHSTEIN, ALBERT F., Electrical Engineer, The Jeffry Mfg. Co., Columbus, Ohio 1928
PUFFER, LOUIS B., Professor of Civil Engineering, University of Vermont, Burlington, Vt. 1922
PUGH, EMERSON M., Associate Professor of Physics, Carnegie Institute of Technology, Pittsburgh, Pa. 1938
PUGSLEY, JOHN B., Professor of Geology and Registrar, Northeastern University, Boston, Mass. 1940
PULLEN, M. W., Associate in Electrical Engineering, Johns Hopkins University, Baltimore, Md. 1909
PULVER, HARRY E., Professor of Civil and Structural Engineering, University of Wisconsin, Madison, Wis. 1929
PUMPHREY, FRED H., Professor and Head, Dept. of Electrical Engineering, Rutgers University, New Brunswick, N. J. **In military service** 1928
PURDIE, K. S., Associate Professor of Mathematics, Virginia Military Institute, Lexington, Va. 1927
PUTNAM, RUSSELL C., Associate Professor of Illumination and Engineering Administration, Case School of Applied Science, Cleveland, Ohio 1927
QUAGLIANO, JAMES V., Instructor in Chemistry, Villanova College, Villanova, Pa. 1941
QUAID, LLOYD J., Instructor in Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. 1931

QUARLES, LAWRENCE R., Associate Professor of Electrical Engineering, University of Virginia, University, Va. 1938

QUATTLEBAUM, ALEXANDER M., Assistant Professor of Civil Engineering, Clemson College, Clemson, S. C. **In military service** 1941

QUENEAU, BERNARD R., Assistant Professor of Metallurgy, Columbia University, New York City 1940

QUERY, LEO H., Assistant Professor of Industrial Engineering, University of Rochester, Rochester, N. Y. 1938

QUIER, KENNETH E., Instructor in Mechanical Technology, Pratt Institute, Brooklyn, N. Y. 1929

QUINN, BAYARD E., Instructor in Machine Design, Cornell University, Ithaca, N. Y. 1942

QUINN, GERALD S., Instructor in Engineering Drawing, Case School of Applied Science, Cleveland, Ohio 1939

RABER, B. F., Professor of Mechanical Engineering, University of California, Berkeley, Calif. 1915

RADASCH, ARTHUR H., Professor and Head, Dept. of Chemical Engineering, Cooper Union, New York City 1939

RADER, LLOYD F., Professor of Civil Engineering, in charge, Highway Engineering and City Planning, University of Wisconsin, Madison, Wis. **In military service** 1925

RADFORD, STANLEY S., Instructor in Drawing and Design, Michigan State College, East Lansing, Mich. 1937

RAEDER, WARREN, Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1938

RAGATZ, ROLAND A., Professor and Chairman, Dept. of Chemical Engineering, University of Wisconsin, Madison, Wis. 1927

RAHM, LOUIS F., Assistant Professor of Mechanical Engineering, Princeton University, Princeton, N. J. 1935

RAMBERG, EIVIND G. F., Instructor in Civil Engineering, Newark College of Engineering, Newark, N. J. 1939

RANDALL, MERLE, Professor of Chemistry, University of California, Berkeley, Calif. 1940

RANDOLPH, EDGAR E., Professor and Head, Dept. of Chemical Engineering, North Carolina State College, Raleigh, N. C. 1932

RANSDELL, CLIFFORD H., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas 1942

RAPPOLT, FRANK A., Assistant Professor of Drafting, College of the City of New York, New York City 1940

RASCHE, WILLIAM H., Professor of Mechanism, Virginia Polytechnic Institute, Blacksburg, Va. 1931

RATH, EDWIN R., Vice President, Power Transmission Council, 53 Park Row, New York, N. Y. 1936

RATHBUN, JOHN C., Professor of Civil Engineering, College of the City of New York, New York City 1925

RAUTENSTRAUCH, WALTER, Professor of Industrial Engineering, Columbia University, New York, N. Y. 1931

RAVITZ, S. FREDERICK, Director, Engineering Experiment Station, University of Utah, Salt Lake City, Utah 1940

RAW, RUTH, Assistant Professor of English, University of Akron, Akron, Ohio 1935

RAY, B. M., Instructor in Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1942

RAYMOND, F. N., Professor of English, University of Kansas, Lawrence, Kans. 1910

RAYNER, WM. H., Associate Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1913
RAYNES, S. HERBERT, Instructor in Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1939
READ, THOMAS T., Vinton Professor of Mining Engineering, Columbia University, New York City 1933
REASER, WILLIAM E., Assistant Professor of Mechanical Engineering, Lafayette College, Easton, Pa. 1942
REBER, LOUIS E., Fiduciary Trust Co., 1 Wall St., New York City. (*Member of Council, 1901–7.*) 1893
RECORD, FRANK A., Research Associate, Harvard University, Cambridge, Mass. 1940
REDDICK, H. W., Professor and Head, Dept. of Mathematics, Cooper Union, New York City 1940
REED, FREDERICK J., Assistant Professor of Mechanical Engineering, Duke University, Box 263, Durham, N. C. 1936
REED, HENRY R., Professor of Electrical Engineering, State University of Iowa, Iowa City, Iowa 1935
REED, JOHN C., Professor and Head, Dept. of Mechanical Engineering, Bucknell University, Lewisburg, Pa. 1929
REED, K. W., Consulting Engineer, 4614 Prospect Ave., Cleveland, Ohio. 1915
REED, MYRIL B., Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1938
REED, PERCY L., Professor and Head, Dept. of Civil Engineering, University of Florida, Gainesville, Fla. 1914
REEKS, MARK R., Assistant Professor of Mathematics, Stevens Institute of Technology, Hoboken, N. J. 1940
REEL, FRED R., Assistant Professor of Mathematics, Illinois Institute of Technology, Chicago, Ill. 1939
REESE, RAYMOND C., Special Instructor in Structural Engineering, University of Toledo, Toledo, Ohio 1933
REICH, HERBERT J., Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1934
REID, CHARLES T., Staff Assistant to Vice President, Douglas Aircraft Co., Inc., 1102 Pacific St., Santa Monica, Calif. 1938
REID, ERNEST A., Associate Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1938
REID, LINCOLN, Instructor in Civil Engineering, College of the City of New York, New York City 1938
REINSCH, BERNHARD P., Professor and Head, Department of Mathematics, Florida Southern College, Lakeland, Fla. 1931
REINTJES, J. FRANK, Assistant Professor of Electrical Engineering, Manhattan College, New York City 1937
REISSNER, HANS, Research Professor of Engineering, Illinois Institute of Technology, Chicago, Ill. 1942
RENNER, WILLIAM E., Head, Dept. of Administrative Engineering, Syracuse University, Syracuse, N. Y. **In military service** 1940
RENWICK, DONALD J., Assistant Professor of Mechanical Engineering, University of North Dakota, Grand Forks, N. D. 1941
REPSCHA, ALBERT H., Associate Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1933
REUKEMA, LESTER E., Associate Professor of Electrical Engineering, University of California, Berkeley, Calif. 1940
REULING, WALTER E., Associate Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. 1929

REW, IRWIN, Trustee of Northwestern University, 217 Dempster St., Evanston, Ill. 1913
REYNOLDS, KENNETH C., Associate Professor of Hydraulics, Massachusetts Institute of Technology, Cambridge, Mass. 1934
RHODES, FRED H., Assistant Professor of Civil Engineering, University of Washington, Seattle, Wash. In military service 1938
RHODES, FRED H., Director, School of Chemical Engineering, Herbert Fisk Johnson Professor of Industrial Chemistry, Cornell University, Ithaca, N. Y. 1941
RHODES, LELAND S., Associate Professor of Civil Engineering, The Pennsylvania State College, State College, Pa. 1925
RHODES, SAM R., Professor and Head, Division of Electrical Engineering, Clemson Agricultural College, Clemson College, S. C. 1927
RHODES, THOMAS J., Chief of Product Control, Ordnance Plant, U. S. Rubber Co., 4325 Ovid Ave., Des Moines, Iowa 1943
RHODES, WALTER K., Professor of Electrical Engineering, Bucknell University, Lewisburg, Pa. 1925
RICE, HAROLD S., Instructor in Mathematics, Wentworth Institute, Boston, Mass. 1943
RICE, HARRIS, Professor of Mathematics, Worcester Polytechnic Institute, Worcester, Mass. 1919
RICE, PAUL P., Assistant Professor of Civil Engineering, Lafayette College, Easton, Pa. 1932
RICE, PHILIP X., Associate Professor of Electrical Engineering, The Pennsylvania State College, State College, Pa. 1931
RICE, ROBERT B., Professor and Head, Dept. of Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1931
RICE, WILLIAM H., Assistant Professor of Welding, Oklahoma A. & M. College, Stillwater, Okla. 1940
RICH, R. E., Associate Professor and Head, Dept. of Chemical Engineering, University of Notre Dame, Notre Dame, Ind. 1936
RICHARDS, HENRY E., Associate Professor of Electrical Engineering, Northeastern University, Boston, Mass. 1935
RICHARDSON, DONALD E., Physicist, Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill. 1929
RICHARDSON, LOUIS A., Assistant Professor of Architectural Engineering, The Pennsylvania State College, State College, Pa. 1938
RICHMOND, ADDISON E., Assistant Professor of Civil Engineering, Howard University, Washington, D. C. 1931
RICHMOND, RUSSELL F., Assistant Testing Engineer, University of Nebraska, Lincoln, Nebr. 1926
RICHTMANN, WILLIAM M., Professor and Head, Dept. of Mechanical Engineering, Colorado School of Mines, Golden, Colo. 1938
RICKER, CLAIRE W., Professor and Head, Dept. of Electrical Engineering, Tulane University, New Orleans, La. 1921
RIDDLE, KENNETH W., Instructor in Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937
RIDINGS, PAUL O., Director of News Bureau, Illinois Institute of Technology, Chicago, Ill. 1942
RIEDESEL, GERHARD A., Assistant Professor of Civil Engineering, University of Idaho, Moscow, Idaho 1942
RIEGEL, JOHN W., Professor of Industrial Relations, University of Michigan, Ann Arbor, Mich. 1941
RIETZ, HENRY LEWIS, Professor and Head of Department of Mathematics, The State University of Iowa, Iowa City, La. 1919

RIFFENBERG, HARRY B., Associate Professor of Chemistry, Virginia Polytechnic Institute, Blacksburg, Va. 1937
RIKER, CHARLES R., Supervisor of Extension Training, Westinghouse E. & M. Co., East Pittsburgh, 101 Woodhaven Drive, Pittsburgh, Pa. .. 1939
RINEHART, H. WADE, Personnel Dept., E. I. du Pont de Nemours & Co., Wilmington, Del. 1941
RISING, JUSTUS, Professor and Head, Dept. of Engineering Drawing, Purdue University, Lafayette, Ind. 1926
RISTEEN, HORACE W., Associate Professor of Mechanical Engineering, Michigan College of M. & T., Houghton, Mich. **In military service** 1935
RITTENHOUSE, L. H., Professor of Electrical Engineering, Chairman, Dept. of Engineering, Haverford College, Haverford, Pa. 1906
RITTER, IRVING F., Instructor in Mathematics, New York University, New York City 1938
RITTERSBUSCH, HARRY F., Assistant Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. 1938
RIX, CLIFFORD N., Associate Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. 1941
RIZZI, ANTHONY V., Instructor in Civil Engineering, College of the City of New York, New York City. **In military service** 1940
ROARK, RAYMOND J., Professor of Mechanics, University of Wisconsin, Madison, Wis. 1919
ROBBINS, ARTHUR G., Professor of Topographical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1894
ROBBINS, JAMES M., Associate Professor of Civil Engineering, Newark College of Engineering, Newark, N. J. 1937
ROBBINS, PAUL H., Supervisor of Wartime Training, City of New York, N. Y. 1939
ROBERT, JAMES M., Dean, College of Engineering, Tulane University, New Orleans, La. 1922
ROBERT, JULES H., Professor of Applied Mechanics, Kansas State College, Manhattan, Kans. 1926
ROBERT, RENE A., Associate Professor of Physics, Ecole Polytechnique, Montreal, Canada. 1942
ROBERTS, CHARLES P., Associate Professor of Mechanical Engineering, The Ohio State University, Columbus, Ohio 1926
ROBERTS, EMERSON B., Assistant to the Vice President, Westinghouse E. & M. Co., Union Bank Bldg., Pittsburgh, Pa. 1919
ROBERTS, ERSKINE G., Assistant Professor of Mechanic Arts, Lincoln University, Jefferson City, Mo. 1941
ROBERTS, MILNOR, Dean, College of Mines, University of Washington, Seattle, Wash. 1910
ROBERTSON, BURTON J., Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. 1922
ROBERTSON, JAMES E., Assistant Professor of Drawing and Design, Michigan State College, East Lansing, Mich. 1938
ROBINSON, DOUGLAS I., Employment Supervisor, Sperry Gyroscope Co., Inc., Brooklyn, N. Y. 1941
ROBINSON, MAX B., Acting Dean, Fenn College, Cleveland, Ohio 1915
ROBINSON, OTTO L., Associate Professor of Fire Protection Engineering, Illinois Institute of Technology, Underwriters Labs., 207 E. Ohio St., Chicago, Ill. 1941
ROBINSON, ROBERT H., Associate Professor of Mathematics, Ecole Polytechnique, Montreal, Canada 1942

ROBSON, FRED B., Instructor in Industrial Engineering and Drawing, Texas Technological College, Lubbock, Texas 1942
ROCKWELL, EDWARD H., Professor Emeritus of Civil Engineering, Lafayette College, Easton, Pa. (*Member of Council, 1919–22.*) 1907
RODE, NORMAN F., Professor of Electrical Engineering, Texas A. & M. College, College Station, Texas 1936
RODMAN, WALTER S., Professor of Electrical Engineering, Dean, University of Virginia, University, Va. (*Vice President, 1926–7; Member of Council, 1919–22.*) 1915
ROE, HARRY B., Professor of Agricultural Engineering, University of Minnesota, University Farm, St. Paul, Minn. 1925
ROEHRIG, GEORGE F., Assistant Professor of Civil Engineering, Lafayette College, Easton, Pa. 1926
ROEMMELE, HERBERT F., Assistant Professor of Mechanical Engineering, Cooper Union, New York City 1927
ROESCH, DANIEL, Professor of Automotive Engineering, Illinois Institute of Technology, Chicago, Ill. 1939
ROGERS, FRED A., Director, Engineering Defense, Illinois Institute of Technology, Chicago, Ill. 1935
ROGERS, FRED S., Professor of Machine Design, Cornell University, Ithaca, N. Y. 1936
ROGERS, H. BARRETT, Professor of Industrial Management, Northwestern University, Evanston, Ill. 1940
ROGERS, H. S., President, Brooklyn Polytechnic Institute, Brooklyn, N. Y. (*Vice President, 1932–33; Member of Council, 1928–31.*) 1922
ROGERS, RAYMOND R., Instructor in Chemical Engineering, Columbia University, New York City 1937
ROHLICH, GERARD A., Assistant Professor of Sanitary Engineering, The Pennsylvania State College, State College, Pa. 1938
ROHR, ERWIN K., Assistant Design Engineer, Generator Dept., General Electric Co., Lynn, Mass. 1940
ROHRBACH, GEORGE E., Associate Professor of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. 1938
ROLLINS, EDWIN B., Professor of Electrical Engineering, Tufts College, Medford, Mass. 1912
ROOP, FRANK S., Assistant Professor of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1936
ROOS, PHILIP K., Instructor in Civil Engineering, The Pennsylvania State College, Du Bois Undergraduate Center, Du Bois, Pa. 1939
ROOT, RALPH E., Professor of Mathematics and Mechanics, Postgraduate School, U. S. Naval Academy, Annapolis, Md. 1914
ROSE, FRANK W., Head, Science Dept., Taft Junior College, Taft, Calif. 1933
ROSE, FRANKLIN O., Associate Professor of Civil Engineering, Brown University, Providence, R. I. 1928
ROSE, LISLE A., Professor and Head, Dept. of Languages, Michigan College of M. & T., Houghton, Mich. 1940
ROSE, LOUIS H., Associate Professor and Acting Head, Dept. of Electrical Engineering, University of Dayton, Dayton, Ohio 1937
ROSE, WILLIAM A., Associate Professor of Structural Engineering, New York University, New York City 1938
ROSELLA, EDWARD G., Instructor in Architectural Engineering, University of Detroit, Detroit, Mich. 1942
ROSENBACH, J. B., Professor of Mathematics, Carnegie Institute of Technology, Pittsburgh, Pa. 1939

ROSS, DAVID E., President, Board of Trustees, Purdue University, Ross Building, Lafayette, Ind. 1931
ROSS, FREDERICK W., Professor and Head, Dept. Geography and Geology, Alfred University, Alfred, N. Y. 1941
ROSS, JOHN A., President, Clarkson College of Technology, Potsdam, N. Y. 1926
ROSSI, BONIFACE E., Director, Welding Division, The Delehanty Institute, 40–35 24th St., Long Island City, N. Y. 1942
ROTH, CHARLES O., JR., Assistant Professor of Civil Engineering, Newark College of Engineering, Newark, N. J. 1932
ROTH, SIDNEY G., Instructor in Mathematics, Cooper Union, New York City 1942
ROUDEBUSH, R. E., Associate Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1932
ROUSH, MYRTLE B., Librarian, Arkansas Polytechnic College, Russellville, Ark. 1942
ROWE, CHARLES E., Professor of Drawing, University of Texas, Austin, Texas 1935
ROWLANDS, THOMAS M., Assistant Professor of General Engineering, University of Washington, Seattle, Wash. 1935
ROWLEY, F. B., Professor and Head, Dept. of Mechanical Engineering; Director, Experimental Engineering Laboratories, University of Minnesota, Minneapolis, Minn. 1910
ROYS, FRANCIS W., Dean of Engineering, Professor and Head, Dept. of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1925
RUBENKOENIG, HARRY, Professor of Railway Mechanical Engineering, Purdue University, Lafayette, Ind. 1920
RUBEY, HARRY, Chairman, Civil Engineering Dept., University of Missouri, Columbia, Mo. (*Member of Council, 1932–35.*) 1917
RUGGLES, EDWARD W., Director, College Extension Division, North Carolina State College, Raleigh, N. C. 1941
RULE, JOHN T., Associate Professor of Engineering Drawing and Descriptive Geometry, Massachusetts Institute of Technology, Cambridge, Mass. 1940
RUNGE, LULU L., Assistant Professor of Mathematics, University of Nebraska, Lincoln, Nebr. 1940
RUSH, HARRY S., Professor of Electrical Engineering, Assistant Dean, North Dakota Agricultural College, Fargo, N. D. 1919
RUSH, PHILIP E., Assistant Professor of Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1939
RUSHTON, J. H., Professor and Head, Dept. of Chemical Engineering, University of Virginia, University, Va. 1935
RUSS, JOHN M., Associate Professor of Engineering Drawing, State University of Iowa, Iowa City, Iowa 1924
RUSSELL, CHESTER, Associate Professor and Acting Head, Dept. of Electrical Engineering, Michigan College of M. & T., Houghton, Mich. 1930
RUSSELL, DONALD M., Instructor in Mechanical Engineering, Rice Institute, Houston, Texas 1942
RUSSELL, FRANK A., Professor of Civil Engineering, University of Kansas Lawrence, Kans. 1922
RUSSELL, JOHN J., Head, Dept. of Chemistry, Franklin Technical Institute, Boston, Mass. 1940
RUTEN, WILLIAM H., Assistant Professor of Practical Mechanics, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1938

RUTH, BURRELL F., Professor of Chemical Engineering, Iowa State College, Ames, Iowa 1936
RUTLEDGE, PHILIP C., Professor of Soil Mechanics, Purdue University, Lafayette, Ind. 1937
RUTTER, M. L., Lieut., C. E. C., U. S. N., Box 311, Parris Island, S. C. .. 1939
RYAN, DAVID G., Associate Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1941
RYCKMAN, SEYMOUR J., Instructor in Civil Engineering, University of Maine, Orono, Me. 1942
RYDER, JOHN D., Associate Professor of Electrical Engineering, Iowa State College, Ames, Iowa 1941
RYON, LEWIS B., JR., Professor of Civil Engineering, Rice Institute, Houston, Texas 1925
SABBAGH, ELIAS M., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1930
SACKETT, R. L., Dean Emeritus, School of Engineering, Pennsylvania State College, 303 Lexington Ave., New York City. (*Member of Council, 1897–1900; 1927–; President, 1927–28.*) **Eleventh Recipient, Lamme Medal (1938)** 1923
SADLER, WALTER C., Associate Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. 1940
SAGEN, GEORGE O., Physics Instructor, Bakersfield Junior College, Bakersfield, Calif. 1934
SAGER, EDWIN H., Instructor in Mechanical Engineering, Washington University, St. Louis, Mo. **In military service** 1939
SAHAG, LEON M., Professor of Machine Design and Drawing, Alabama Polytechnic Institute, Auburn, Ala. 1927
SALMA, EMANUEL A., Instructor in Mechanical Engineering, Cooper Union, New York, N. Y. 1930
SALTZER, BERTRAM H., Supervisor of Engineering Training, Wright Aero. Corp., Paterson, N. J. 1936
SAMPSON, MARTIN W., Instructor in Administrative Engineering, Cornell University, Ithaca, N. Y. 1941
SANDERS, THOMAS K., Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. 1941
SANDERS, WILLIAM B., Associate Professor of Applied Mechanics and Chemical Engineering, Purdue University, Lafayette, Ind. 1922
SANDORF, IRVING J., Associate Professor of Electrical Engineering, University of Nevada, Reno, Nev. 1938
SANDSTEDT, CARL E., Professor of Civil Engineering, A. & M. College of Texas, College Station, Texas 1938
SANFORD, CARL N., Assistant Professor of Aeronautical Engineering, North Carolina State College, Raleigh, N. C. 1940
SANTRY, ISRAEL W., Instructor in Civil Engineering, Southern Methodist University, Dallas, Texas 1942
SARBACHER, ROBERT I., Assistant Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. **In military service** 1941
SARTAIN, CARL C., Instructor in Physics, University of Alabama, University, Ala. **In military service** 1940
SATTERFIELD, HOWARD E., Professor of Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1932
SATULLO, ANTHONY R., Instructor in Electrical Engineering, University of Detroit, Detroit, Mich. 1941

SAVANT, D. P., Professor and Head, Dept. of Electrical Engineering, Dean of Engineering, Georgia School of Technology, Atlanta, Ga. (*Member of Council, 1940–43.*) 1917

SAVILLE, THORNDIKE, Dean, College of Engineering, New York University, New York City 1915

SAWYER, RALPH A., Assistant Professor of Engineering Drafting, University of Maine, Orono, Me. 1941

SAXTON, REN G., Professor and Head, Dept. of Civil Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1925

SAYRE, MORTIMER F., Professor of Applied Mechanics, Union College, Schenectady, N. Y. 1917

SCAMMAN, WILLIAM F., Associate Professor of English, University of Maine, Orono, Me. 1927

SCARTH, VIRGIL, Associate Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940

SCHAEFER, VERNON G., Assistant Professor of Psychology-Extension, The Pennsylvania State College, State College, Pa. 1942

SCHAFFNER, ROBERT M., Chemical Engineer, Research Staff, Standard Oil Co., Whiting, Ind. 1938

SCHEALER, SAMUEL R., Professor and Head, Dept. of Electrical Engineering, Vanderbilt University, Nashville, Tenn. 1911

SCHEIFLEY, CLAUDE K., Assistant Professor of Modern Languages and History, Worcester Polytechnic Institute, Worcester, Mass. 1939

SCHELKUNOFF, SERGEI A., Consultant in Electromagnetic Theory, Bell Telephone Labs., 463 West St., New York City 1940

SCHELL, ERWIN H., Professor in Charge of Business and Engineering Administration, Massachusetts Institute of Technology, Cambridge, Mass. 1940

SCHILLING, E. W., Professor and Head, Dept. of Electrical Engineering, Acting Dean, Montana State College, Bozeman, Mont. 1935

SCHMIDT, HARRY P., Assistant Professor of Physics, Pratt Institute, Brooklyn, N. Y. 1930

SCHNEIDEWIND, RICHARD, Associate Professor of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich. 1940

SCHOCK, EDSON I., Assistant Professor of Mechanical Engineering, Rhode Island State College, Kingston, R. I. 1937

SCHODER, ERNEST W., Professor of Experimental Hydraulics, Cornell University, Ithaca, N. Y. 1934

SCHOENBORN, E. M., Assistant Professor of Chemical Engineering, University of Delaware, Newark, Del. 1935

SCHOLER, CHARLES H., Professor of Applied Mechanics, Kansas State College, Manhattan, Kans. 1925

SCHOMMER, JOHN T., Professor of Industrial Chemistry, Athletic Director, Director of Placement, Trustee, Illinois Institute of Technology, Chicago, Ill. 1928

SCHOONOVER, REX H., Professor and Head, Dept. of Engineering Mechanics, Wayne University, Detroit, Mich. 1937

SCHRADER, HERMAN J., Research Associate Professor of Railway Mechanical Engineering, University of Illinois, Urbana, Ill. 1925

SCHRAMM, E. FRANK, Chairman, Dept. of Geology, University of Nebraska, Lincoln, Nebr. 1940

SCHRENK, WALTER T., Professor and Head, Dept. of Chemical Engineering and Chemistry, Missouri School of Mines, Rolla, Mo. 1939

SCHROEDER, WILLIAM, Research Engineer, Lockheed Aircraft Corp., Burbank, Calif. 1929

SCHUHMANN, REINHARDT, Assistant Professor of Mineral Dressing, Massachusetts Institute of Technology, Cambridge, Mass. 1942

SCHUBMEHL, RAYMOND J., Professor of Civil Engineering, Acting Dean, University of Notre Dame, Notre Dame, Ind. 1938

SCHUCK, ROBERT F., Assistant Professor of Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn. 1925

SCHULTE, WILLIAM C., Chief Metallurgist, Curtis-Wright Corp., Caldwell, N. J. 1938

SCHULTZ, F. V., Instructor in Electrical Engineering, Michigan State College, East Lansing, Mich. 1939

SCHULTZ, ELMER H., Assistant Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. 1938

SCHUMANN, CHARLES H., JR., Associate Professor of Drawing, Columbia University, New York City. (Head, Drafting Defense Training Inst.) 1925

SCHUTZ, HARALD, Instructor in Power Engineering, Dartmouth College, Hanover, N. H. 1942

SCHUTZ, PHILIP W., Assistant Professor of Chemical Engineering, Columbia University, New York City 1939

SCHWANTES, ARTHUR J., Professor and Chief, Division of Agricultural Engineering, University of Minnesota, St. Paul, Minn. 1926

SCHWARTZ, FRANK L., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1930

SCHWARZLOSE, PAUL F., Instructor in Electrical Engineering, University of Illinois, Urbana, Ill. 1942

SCHWEIZER, PAUL E., Assistant Professor of Mechanical Engineering, Newark College of Engineering, Newark. N. J. 1926

SCHWIEGER, ALBERT J., Professor and Head, Dept. of Economics, Government and Business, Worcester Polytechnic Institute, Worcester, Mass. 1938

SCIPIO, L. A., Dean and Professor of Mechanical Engineering, Robert College, Istanbul, Turkey 1910

SCOFIELD, J. HARRY, Associate Professor of Mechanical Engineering, Colorado State College, Ft. Collins, Colo. 1938

SCOFIELD, WALTER F., Instructor in Civil Engineering, Tulane University, New Orleans, La. 1940

SCOTT, CHARLES F., Emeritus, Professor of Electrical Engineering, Yale University, New Haven, Conn. (*President, 1921–2, 1922–3; Member of Council, 1907–10; 1917–20; 1921–; chairman, Board of Investigation and Coördination, 1922–33.*) **Third Recipient, Lamme Medal (1930).** 1904

SCOTT, ERMAN O., Assistant Professor of Civil Engineering and Engineering Mechanics, University of Toledo, Toledo, Ohio 1941

SCRIMSHAW, STEWART, Professor of Economics and Industrial Relations, Marquette University, Milwaukee, Wis. 1925

SEABURY, GEORGE T., Secretary, American Society of Civil Engineers, 33 West 39th Street, New York City. (*Member of Council, 1940–43.*) 1926

SEAGRAVES, WAYLAND P., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. 1937

SEARLE, FREDERICK E., Superintendent, Ford Industrial Schools, Ford Motor Co., Farmington, Mich. 1942

SEARLES, CHARLES L., Public and Civic Relations Dept., Western Electric Company, Kearny, N. J. 1930

SEATON, R. A., Dean, Division of Engineering, Director, Engineering Experiment Station, Kansas State College, Manhattan, Kans. (*President, 1932–33; Vice President, 1930–31; Member of Council, 1926–29; 1930–.*) 1912

SEAVER, HENRY L., Professor of History, Massachusetts Institute of Technology, Cambridge, Mass. 1908

SEAVER, WILLIAM N., Librarian, Institute Library, Massachusetts Institute of Technology, Cambridge, Mass. 1941

SECHRIST, GILBERT H., Professor and Chairman, Dept. of Electrical Engineering, University of Wyoming, Laramie, Wyo. 1927

SEEGRIST, WALTER H., Associate Professor of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1934

SEELEY, LAUREN E., Associate Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1935

SEELEY, WALTER J., Professor and Chairman, Dept. of Electrical Engineering, Duke University, Durham, N. C. 1927

SEELY, F. B., Professor and Head, Dept. of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. (*Member of Council, 1937–40*) 1913

SEELY, J. FRANK, Instructor in Chemical Engineering, North Carolina State College, Raleigh, N. C. 1941

SEELY, SAMUEL, Instructor in Electrical Engineering, College of the City of New York, New Yory City (on leave M. I. T.) 1942

SEIBERT, CHARLES B., Assistant Professor of Electrical Engineering, West Virginia University, Morgantown, W. Va. 1942

SEIDL, JULIUS C. G., Director of Training Safety, Ranger Aircraft Engines, 184–10 Jamaica Ave., Jamaica, L. I. 1935

SELLERS, GABE A., Professor of Metallurgy and Metallography, Kansas State College, Manhattan, Kans. 1926

SELVIDGE, HARNER, Associate Professor of Electrical Engineering, Kansas State College, Manhattan, Kansas 1938

SERVISS, FREDERICK L., Professor of Geology, Purdue University, Lafayette, Ind. 1929

SESSUMS, ROY T., Dean, School of Engineering, Louisiana Polytechnic Institute, Ruston, La. **In military service** 1939

SETCHELL, JOHN E., Assistant Professor of Mechanical Engineering, Brooklyn Polytechnic Institute, Brooklyn, N. Y. 1927

SETTE, FRANCIS J., Blacksburg, Va.; Special Technical Assistant to the Secretary, Dept. of Agriculture, 4701 Conn. Ave., Apt. 502, Washington, D. C. 1925

SEULBERGER, FERDINAND G., Professor and Chairman, Dept. of Industrial Relations, Northwestern Technological Institute, Evanston, Ill. 1940

SEVERNS, WILLIAM H., Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1934

SEWARD, H. L., Robert Higgin Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1910

SEXTON, F. H., President, Nova Scotia Technical College, Director, Technical Education for Nova Scotia, Halifax, Nova Scotio 1908

SHAFFER, HAROLD A., Assistant Professor of Electrical Engineering and Drawing, Bucknell University, Lewisburg, Pa. 1927

SHALLENBERGER, WILLIAM H., Instructor in Mechanical Engineering, University of Southern California, Los Angeles, Calif. 1940

SHANK, JACOB RALPH, Professor of Civil Engineering, Assistant Director, Engineering Experiment Station, The Ohio State University, Columbus, O. 1919

SHARP, H. OAKLEY, Professor of Geodesy and Transportation Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1935
SHAW, CLYDE E., Associate Professor of Electrical Engineering, Tri-State College, Angola, Ind. 1942
SHAW, G. REED, Assistant Professor of Geodesy and Transportation, Rensselaer Polytechnic Institute, Troy, N. Y. 1940
SHAW, H. B., Professor of Industrial Engineering, North Carolina State College, Raleigh, N. C. 1907
SHEDD, PAUL C., Associate Professor of Electrical Engineering, Newark College of Engineering, Newark, N. J. 1928
SHEDD, THOMAS C., Professor of Structural Engineering, University of Illinois, Urbana, Ill. 1925
SHEIRY, EDWARD S., Professor and Head, Dept. of Civil Engineering, Cooper Union, New York City 1928
SHELTON, EDWARD E., Instructor in Electrical Engineering, Cooper Union, New York City 1942
SHENK, D. H., Associate Professor of Mechanical Engineering, Clemson Agricultural College, Clemson College, S. C. 1928
SHEPPARD, H. S., Apparatus Staff Engineer, Bell Telephone Labs., Inc., 195 Broadway, New York, N. Y. 1914
SHERLOCK, ROBERT H., Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich. 1925
SHERMAN, GEORGE W., JR., Associate Professor of Metallurgy, Purdue University, Lafayette, Ind. 1929
SHERRILL, RICHARD E., Professor and Head, Dept. of Oil and Gas, University of Pittsburgh, Pittsburgh, Pa. 1942
SHERWOOD, NOBLE P., Instructor in Mechanical Engineering, University of Wisconsin, Madison, Wis. 1941
SHERWOOD, ROBERT S., Instructor in Mechanical Engineering, Iowa State College, Ames, Iowa. **In military service** 1940
SHIELDS, BERT A., Lt. Comdr., USNR, Peru, Ind. 1942
SHIELS, K. G., Associate Professor of Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. 1937
SHIGLEY, JOSEPH E., Instructor in Mechanical Engineering, Clemson College, Clemson, S. C. 1942
SHILTS, WALTER L., Head, Dept. of Civil Engineering, University of Notre Dame, Notre Dame, Ind. 1936
SHIPLEY, E. D., Associate Professor of Electrical Engineering, University of Tennessee, Knoxville, Tenn. 1941
SHIRES, L. B., Associate Professor of Chemical Engineering, New Mexico State College, State College, N. M. 1940
SHOOP, C. F., Professor and Head, Division of Steam Engineering, University of Minnesota, Minneapolis, Minn. 1906
SHOREY, LAWRENCE F., Assistant Professor of Electrical Engineering, University of Vermont, Burlington, Vt. 1926
SHORT, BRYON E., Professor of Mechanical Engineering, University of Texas, Box 1659, Univ. Sta., Austin, Texas 1931
SHORT, R. L., Principal, Ashland School, 3921 N. Newstead St., St. Louis, Mo. 1902
SHORT, W. IRWIN, Associate Professor of Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. **In military service** 1934
SHREVE, DARRELL R., Stress Analyst, McDonnell Aircraft Co., St. Louis Mo. 1940
SHREVE, R. NORRIS, Professor of Chemical Engineering, Purdue University, Lafayette, Ind. 1930

SHUMAN, EVERETT C., Assistant Professor of Civil Engineering, Illinois Institute of Technology, Chicago, Ill. 1939
SHYBEKAY, DERSO S., Associate Professor and Acting Head, Dept. of Industrial Engineering, University of Alabama, University, Ala. 1942
SIBILA, KENNETH F., Instructor in Electrical Engineering, University of Akron, Akron, Ohio 1941
SIBLEY, ALDEN K., Engineer of Construction, U. S. Engineers Office, 120 Wall St., New York, N. Y. 1940
SIEGFRIED, VICTOR, Assistant Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934
SIEPERT, ALBERT F., Dean of Education, Bradley Polytechnic Institute, Peoria, Ill. 1942
SILHA, HENRY W., Assistant Professor of Mechanical Engineering, University of Idaho, Moscow, Idaho 1941
SILVEY, O. W., Professor and Head, Dept. of Physics, A. & M. College of Texas, College Station, Tex. 1917
SIMARD, JEAN-MARCEL, Assistant Professor of Chemistry, Ecole Polytechnique, Montreal, Canada 1942
SIMESTER, JOHN H., Associate Professor of Mathematics, University of Louisville, Louisville, Ky. 1930
SIMMANG, CLIFFORD M., Instructor in Mechanical Engineering, A. & M. College of Texas, College Station, Texas 1939
SIMMONS, ALLEN, Dean, Linsly Institute of Technology, Wheeling, W. Va. 1942
SIMON, GEORGE H., Associate Professor of Mechanical Engineering, Louisiana State University, University, La. 1935
SIMON, HERBERT A., Assistant Professor of Political Science, Illinois Institute of Technology, Chicago, Ill. 1942
SIMONDS, ROLLIN H., Instructor in Industrial Engineering, Illinois Institute of Technology, Chicago, Ill. 1942
SIMONS, HOWARD P., Assistant Professor of Chemical Engineering, West Virginia University, Morgantown, W. Va. 1941
SIMPSON, WILLIAM M., Stress Analyst, Douglas Aircraft Co., Santa Monica, Calif. 1939
SIMRALL, HARRY C., Assistant Professor of Electrical Engineering, Mississippi State College, State College, Miss. 1936
SIMS, CHARLES E., Lecturer in Civil Engineering, University of Southern California, Los Angeles, Calif. 1941
SIMS, ELLIS M., Assistant Professor of Mechanical Engineering, University of Oklahoma, Norman, Okla. 1937
SIMS, JAMES R., Instructor in Civil Engineering, The Rice Institute, Houston, Texas 1942
SINGER, FERDINAND L., Assistant Professor of Engineering Mechanics, New York University, New York, N. Y. 1930
SIROKY, EDMOND, Associate Professor of Applied Mathematics, Washington University, St. Louis, Mo. 1930
SISKIND, ROBERT P., Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1938
SITZ, EARL L., Associate Professor of Electrical Engineering, Kansas State College, Manhattan, Kansas 1932
SIZELOVE, OLIVER J., Instructor in Physics, Newark College of Engineering, Newark, N. J. 1941
SKELLEY, CHARLES L., Science Editor, College Dept., The Macmillan Company, 60 Fifth Avenue, New York City 1940
SKELTON, RUSSELL R., Associate Professor of Civil Engineering, University of New Hampshire, Durham, N. H. 1936

SKILES, W. V., Dean, Georgia School of Technology, Atlanta, Ga. 1919
SKOGLUND, VICTOR J., 4939 Canterbury Dr., San Diego, Calif. 1938
SLACK, EDGAR P., Associate Professor of Physics, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1927
SLACK, FRANCIS G., Professor and Chairman, Dept. of Physics, Vanderbilt University, Nashville, Tenn. 1925
SLANTZ, FRED W., Professor of Graphics, Director of Placement, Lafayette College, Easton, Pa. 1930
SLAVIN, WILLIAM A., Assistant Professor of Electrical Engineering, Villanova College, Villanova, Pa. 1939
SLAYMAKER, P. K., Professor of Machine Design, University of Nebraska, Lincoln, Nebr. 1910
SLAYMAKER, ROBERT R., Professor of Machine Design, Case School of Applied Science, Cleveland, Ohio 1937
SLICHTER, W. I., Professor Emeritus, Electrical Engineering, Columbia University, New York, N. Y. 1911
SLOAN, ROYAL D., Dean, College of Mechanic Arts and Engineering, State College of Washington, Pullman, Wash. 1926
SLOAN, WILLIAM A., Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1937
SLOANE, ALVIN, Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1927
SLOBIN, HERMAN L., Professor and Head of Department of Mathematics, University of New Hampshire, Durham, N. H. 1923
SLUSS, A. H., Professor of Mechanical Engineering, University of Kansas, Lawrence, Kans. 1915
SMAIL, LLOYD L., Professor of Mathematics, Lehigh University, Bethlehem, Pa. 1936
SMALL, ERIC H., Instructor in Mechanical Engineering, New York University, New York, N. Y. 1938
SMITH, ALVA L., Assistant Professor of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1942
SMITH, EARL B., Associate Professor of Mechanical Engineering, College of City of New York, New York, N. Y. 1926
SMITH, EDWARD F., Associate Professor of Electrical Engineering, University of Florida, Gainesville, Fla. 1935
SMITH, ELLIOTT D., Master, Saybrook College, Professor of Economics, Yale University, New Haven, Conn. 1928
SMITH, ELMER G., Professor of Physics, A. & M. College of Texas, College Station, Texas 1938
SMITH, FRANK H., Assistant Professor of Mechanism and Engineering Drawing, University of Michigan, Ann Arbor, Mich. **In military service** 1939
SMITH, FRANK M., Professor of Civil Engineering, North Texas Agricultural College, Arlington, Texas 1931
SMITH, FINLEY W., Associate Professor of Electrical Engineering, Lafayette College, Easton, Pa. 1933
SMITH, GEORGE B., Instructor in Engineering Drawing, The Pennsylvania State College, State College, Pa. 1939
SMITH, GEORGE I., Assistant Professor of Civil Engineering, University of Notre Dame, Notre Dame, Ind. 1942
SMITH, G. WALLACE, Professor and Head, Dept. of Engineering Mechanics, North Carolina State College, Raleigh, N. C. 1937
SMITH, JAMES H., Assistant Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. 1940

SMITH, JAMES O., Instructor in Theoretical and Applied Mechanics, University of Illinois, 721 N. El Paso St., El Paso, Texas 1940
SMITH, MARVIN W., Vice President in charge of Engineering, Westinghouse E. & M. Co., Pittsburgh, Pa. 1942
SMITH, OTTO J. M., Instructor in Electrical Engineering, Tufts College, Medford, Mass. 1942
SMITH, OTTO M., Professor of Chemical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
SMITH, PAUL C., Associate Professor of Electrical Engineering, University of Akron, Akron, Ohio 1925
SMITH, RALPH A., Instructor in Mechanical Engineering, Tufts College, Medford, Mass. 1922
SMITH, RICHARD H., Professor of Aeronautic Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1933
SMITH, ROGER K., Instructor in Engineering Drawing, Iowa State College, Ames, Iowa 1939
SMITH, SILAS R., R. R. 3, Anderson, Ind. **In military service** 1939
SMITH, THEODORE T., Professor of Experimental Physics, University of Nebraska, Lincoln, Nebr. 1925
SMITH, THOMAS D., Assistant Professor of Civil Engineering, University of Delaware, Newark, Del. 1938
SMITH, VICTOR G., Associate Professor of Electrical Engineering, University of Toronto, Toronto, Ont., Canada 1939
SMITH, WILLIAM G., Professor Emeritus, Northwestern Technological Institute, 161 Beechwood Dr., Packanah, N. J. 1925
SMITH, W. SHERMAN, Assistant Professor of Civil Engineering, Toledo University, Toledo, Ohio 1930
SMUTZ, F. A., Professor of Engineering Drawing and Descriptive Geometry, Kansas State College, Manhattan, Kansas 1936
SNADER, DAVID L., Professor of Civil Engineering, Stevens Institute of Technology, Hoboken, N. J. 1939
SNOOK, RAYMOND C., Assistant Professor of Machine Design, Alabama Polytechnic Institute, Auburn, Ala. 1942
SNOW, CHAS. H., Emeritus Dean, College of Engineering, New York University, 12 Lake Ave., Yonkers, N. Y. 1895
SNYDER, M. K., Head, Dept. of Civil Engineering, Professor of Sanitary Engineering, Washington State College, Pullman, Wash. 1927
SOBEY, ALBERT, Director, General Motors Institute of Technology, Flint, Mich. 1923
SODERSTROM, E. D., Associate Professor of Engineering Shop, Oklahoma A. & M. College, Stillwater, Okla. 1940
SOHON, HARRY, Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. 1942
SOLBERG, HARRY L., Head, School of Mechanical and Aeronautical Engineering, Purdue University, Lafayette, Ind. 1924
SOLLENBERGER, NORMAN J., Instructor in Civil Engineering, Princeton University, Princeton, N. J. 1936
SOLT, MARVIN R., Associate Professor of Mathematics, University of New Hampshire, Durham, N. H. 1931
SORENSEN, HARRY A., Assistant Professor of Mechanical Engineering, Pennsylvania State College, State College, Pa. 1938
SORENSEN, R. W., Professor of Electrical Engineering, California Institute of Technology, Pasadena, Calif. (*Vice President, 1939–40; Member of Council 1937–40.*) 1912

SORENSON, ALFRED E., Associate Professor of Mechanical Engineering, Princeton University, Princeton, N. J. 1931
SPAFFORD, W. F., Professor and Head, Dept. of Business Administration, Rensselaer Polytechnic Institute, Troy, N. Y. 1941
SPAGNUOLO, JOSEPH E., Assistant Professor of Architectural Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1939
SPAHR, ROBERT H., Administrative Chairman, Division of Cooperative Programs, General Motors Institute of Technology, Flint, Mich. ... 1928
SPARKS, FRED W., Professor of Mathematics, Texas Technological College, Lubbock, Texas 1940
SPEAR, JOSEPH, Professor and Chairman, Dept. of Mathematics, Northeastern University, Boston, Mass. 1926
SPEARS, SHOLTO M., Associate Professor of Civil Engineering, Illinois Institute of Technology, Chicago, Ill. 1935
SPEIDEN, HENRY W., Head, Dept. of Civil Engineering, West Virginia University, Morgantown, W. Va. 1937
SPENCE, THOMAS R., Vice-Director, Engineering Experiment Station, A. & M. College of Texas, College Station, Texas 1942
SPENCER, F. A., Professor of Electrical Engineering in charge of Dept., Norwich University, Northfield, Vt. 1920
SPENCER, HENRY C., Chairman, Dept. of Technical Drawing, Illinois Institute of Technology, Chicago, Ill. 1931
SPENCER, HERBERT L., President, Pennsylvania College for Women; Coordinator, E. S. M. W. T., Carnegie Inst. Tech., Penna. State College, Univ. of Pittsburgh, Pittsburgh, Pa. 1942
SPENCER, ROBERT L., Dean of Engineering, University of Delaware, Newark, Del. (*Member of Council, 1942–45.*) 1928
SPENCER, W. R., Professor of Civil Engineering, University of Arkansas, Fayetteville, Ark. 1926
SPINDLER, WILLIAM A., Assistant Professor of Metal Processing, University of Michigan, Ann Arbor, Mich. 1940
SPINNEY, L. B., Professor and Head, Dept. of Physics, Iowa State College, Ames, Ia. 1899
SPRIEGEL, WILLIAM R., Professor and Chairman, Dept. of Management, Northwestern University, Evanston, Ill. 1940
SPRINGER, CLIFFORD H., Associate Professor of General Engineering Drawing, University of Illinois, Urbana, Ill. 1927
SPRINGER, GEORGE P., Associate Professor of Civil Engineering, Purdue University, Lafayette, Ind. 1930
SPURLOCK, BENJAMIN H., Assistant Professor of Mechanical Engineering, University of Colorado, Boulder, Colo. 1940
SPRY, FREDERICK J., Instructor in Surveying, Cornell University, Ithaca, N. Y. 1941
SQUIRE, EDWARD J., Professor and Head, Dept. of Structural Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1929
ST. CLAIR, O. A., Professor and Head, Dept. of Industrial Engineering, Texas Technological College, Lubbock, Texas 1934
ST. PETER, W. N., Professor of Physics, University of Pittsburgh, Pittsburgh, Pa. 1928
STACE, F. N., Editor, New Zealand Electrical Journal, P.O. Box 1572, Wellington, C 1, N. Z. 1939
STAINTON, ROBERT S., Associate Professor of General Engineering, Bradley Polytechnic Institute, Peoria, Ill. 1941
STALEY, HOWARD R., Assistant Professor of Building Construction, Massachusetts Institute of Technology, Cambridge, Mass. 1940

STALKER, EDWARD A., Professor and Chairman, Dept. Aeronautical Engineering, University of Michigan, Ann Arbor, Mich. 1940
STANLEY, CASSIUS M., Professor and Head, Dept. of Textile Engineering, Texas Technological College, Lubbock, Texas 1941
STANLEY, ROBERT L., Instructor in Civil Engineering, Union College, Schenectady, N. Y. 1942
STANLEY, WILLIAM E., Professor of Sanitary Engineering, Cornell University, Ithaca, N. Y. **In military service** 1936
STANTON, CHAS. B., Supervisor, Evening and Part Time Classes and Summer Session; Administrator, E. S. M. D. T., Carnegie Institute of Technology, Pittsburgh, Pa. 1915
STAPLES, ARTHUR J., Assistant Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1934
STAPLEY, EDWARD R., Professor of Civil Engineering, Acting Dean, Oklahoma A. & M. College, Stillwater, Okla. 1926
STARK, LAWRENCE E., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas 1942
STARR, CHARLES J., Associate in Mechanical Engineering, University of Illinois, Urbana, Ill. 1921
STAUDER, LAWRENCE F., Associate Professor of Electrical Engineering, University of Notre Dame, Notre Dame, Ind. 1938
STAVELY, EARL B., Professor of Electrical Engineering, The Pennsylvania State College, State College, Pa. 1920
STEARNS, FREDERICK A., Associate Professor of Mechanical Engineering, Northeastern University, Boston, Mass. 1926
STEARNS, JOYCE C., Professor of Physics, University of Denver, Denver, Colo. 1941
STEEL, ERNEST W., Professor and Head, Dept. of Municipal and Sanitary Engineering, A. & M. College of Texas, College Station, Texas . 1926
STEELE, ARLO L., Instructor in Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
STEINBERG, S. S., Dean, College of Engineering, University of Maryland, College Park, Md. 1935
STEINMAN, D. B., Consulting Engineer, 117 Liberty St., New York, N. Y. 1910
STELZNER, WILLIAM B., Professor and Head, Dept. of Electrical Engineering, University of Arkansas, Fayetteville, Ark. 1914
STEMPEL, W. M., Assistant Professor of Physics, Stevens Institute of Technology, Hoboken, N. J. 1928
STEPHAN, ERICH R., Assistant Professor of Mechanical Engineering, Tulane University, New Orleans, La. 1938
STEPHENSON, EUGENE A., Professor and Head, Dept. of Petroleum Engineering, University of Kansas, Lawrence, Kansas 1938
STETKEWICZ, JOSEPH D., Associate Professor of Mechanical Engineering, Rutgers University, New Brunswick, N. J. 1942
STETSON, GEORGE A., Editor, American Society of Mechanical Engineers, 29 West 39th Street, New York City. (*Member of Council, 1931–4.*) 1926
STEVASON, CARL C., Assistant Professor of Engineering Drawing, Notre Dame University, Notre Dame, Ind. 1942
STEVENS, A. C., Manager, Educational Sales Section, General Electric Co., Schenectady, N. Y. 1912
STEVENS, DON S., Engineering Personnel Officer, Iowa State College, Ames, Iowa. **In military service** 1938
STEVENS, HOWARD E., Associate Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1934

STEVENS, ROE L., Associate Professor of Civil Engineering, Illinois Institute of Technology, Chicago, Ill. 1937
STEVENS, WILLIAM J., Associate Professor of Mechanical Engineering, Drexel Institute, Philadelphia, Pa. 1929
STEVENSON, ALEXANDER R., JR., Assistant to Vice President in Charge of Engineering, General Electric Co., Schenectady, N. Y. 1938
STEVENSON, WILLIAM D., Assistant Professor of Electrical Engineering, Clemson Agricultural College, Clemson College, S. C. 1941
STEWART, EARL H., Assistant Professor of Drawing and Design, Michigan State College, East Lansing, Mich. 1925
STEWART, FREDERIC C., Professor of Mechanical Engineering, The Pennsylvania State College, State College, Pa. 1938
STEWART, G. W., Professor and Head, Dept. of Physics, State University of Iowa, Iowa City, Ia. 1910
STEWART, JAMES W., Assistant Professor of Mining Engineering, University of Illinois, Urbana, Ill. 1939
STEWART, LOWELL O., Professor and Head, Dept. of Civil Engineering, Iowa State College, Ames, Iowa 1927
STEWART, V. T., Professor of Chemistry, Newark College of Engineering, Newark, N. J. 1923
STIEFEL, KARL J., Engineer, Raytheon Mfg. Co., Waltham, Mass. 1940
STIENING, FRANK H., Professor and Head, Dept. of Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1940
STILES, WILLIAM B., Assistant Professor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa 1938
STIMSON, STEPHEN K., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. 1936
STINSON, HOYLE E., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. 1941
STINSON, KARL W., Professor of Automotive Engineering, The Ohio State University, Columbus, Ohio 1924
STITZ, ERWIN O., Instructor in Applied Mechanics, Purdue University, Lafayette, Ind. 1942
STOCK, ORION L., Professor of Drawing and Descriptive Geometry, Rose Polytechnic Institute, Terre Haute, Ind. 1929
STOCKER, GEORGE P., Dean, College of Engineering, Head, Dept. of Civil Engineering, University of Arkansas, Fayetteville, Ark. 1921
STOCKING, ERNEST J., Assistant Chief, Examining Division, U. S. Civil Service Commission, Washington, D. C. 1939
STOCKWELL, FRANK C., Anson Wood Burchard Professor of Electrical Engineering, Dean, Graduate School, Stevens Institute of Technology, Hoboken, N. J. 1914
STOEVER, HERMAN J., Associate Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1942
STOKER, JAMES J., Associate Professor of Mathematics, New York University, New York City 1938
STOLWORTHY, EDWARD H., Assistant Professor of Mechanical Engineering, University of New Hampshire, Durham, N. H. 1923
STONE, OLIVER M., Assistant Professor of Engineering Drawing, Case School of Applied Science, Cleveland, Ohio 1928
STONE, ROBERT L., North Carolina State College, Raleigh, N. C. 1937
STORK, WILFORD L., Assistant Professor of Drafting, College of the City of New York, New York City 1939
STOUT, MELVILLE B., Associate Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. 1929

STRAITON, A. W., Professor of Electrical Engineering, Texas College of Arts and Industries, Kingsville, Texas 1939
STRALEY, HARRISON W., Board of Economic Warfare, Princeton, W. Va. 1939
STRANE, ARCHIBALD J., Instructor and Head, Mathematics Dept., Duluth Junior College, Duluth, Minn. 1932
STRATE, J. TAYLER, Professor and Head, Dept. of Mechanical Engineering, Colorado State College, Ft. Collins, Colo. 1932
STRATTON, LEON D., Professor of Chemistry, Dean of Men, Drexel Institute of Technology, Philadelphia, Pa. 1937
STRATTON, WILLIAM T., Professor and Head, Dept. of Mathematics, Kansas State College, Manhattan, Kansas 1938
STRAUB, LORENZ G., Professor of Hydraulics, Director, St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis, Minn. (*Member of Council, 1939–42.*) 1930
STRAW, JOHN A., Instructor in Mathematics, Rose Polytechnic Institute, Terre Haute, Ind. 1939
STREET, WILLIAM E., Professor and Head, Dept. of Engineering Drawing, Texas A. & M. College, College Station, Texas 1929
STREETER, VICTOR L., Associate Professor of Civil Engineering, Illinois Institute of Technology, Chicago, Ill. 1942
STREUBEL, ERNEST J., Dean, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1925
STROBEL, CHARLES F., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. 1941
STROHM, RUFUS T., Dean of the Faculty, International Correspondence School, Scranton, Pa. 1938
STRONG, EVERETT M., Associate Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. 1939
STRONG, RALPH K., Professor of Chemistry and Chemical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1936
STUART, HARLAND F., Assistant Professor of Mechanical Engineering, Rhode Island State College, Kingston, R. I. 1942
STUART, M. C., Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pa. 1921
STUBBS, FRANK W., JR., Professor and Head, Dept. of Civil Engineering, Rhode Island State College, Kingston, R. I. 1933
STUCKEY, JASPER L., Professor and Head, Dept. of Geology and Geological Engineering, North Carolina State College, Raleigh, N. C. .. 1939
STURMER, ANNA M., Associate Professor of English, Kansas State College, Manhattan, Kansas 1935
SUBLET, FRANK G., Lecturer in Electrical Engineering Design, University of Melbourne, Kew, Melbourne, E5, Australia 1934
SULLIVAN, FRANCIS J., Instructor in Machine Design, Kansas State College, Manhattan, Kansas. **In military service** 1938
SULLIVAN, GEO. L., Dean, College of Engineering, University of Santa Clara, Santa Clara, Calif. 1912
SUMMERS, ROBERT E., Associate Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn 1939
SUMMEY, GEORGE, JR., Professor and Head, Dept. of English, A. & M. College of Texas, College Station, Tex. 1919
SUMWALT, ROBERT L., Professor and Head, Dept. of Civil Engineering, University of South Carolina, Columbia, S. C. 1933
SUPPLE, LEE F., Professor of Chemistry,, Illinois Institute of Technology, Chicago, Ill. 1939

SUTHERLAND, HALE, Professor and Head, Dept. of Civil Engineering, Lehigh University, Bethlehem, Pa. 1914
SUTHERLAND, LEWIS B., Associate Professor of Architectural Engineering, University of Colorado, Boulder, Colo. 1932
SUTTIE, ROSCOE H., Associate Professor of Civil Engineering, Yale University, New Haven. Conn. 1912
SVENSEN, CARL L., Member-Secretary, Texas State Board of Registration for Professional Engineers, 511 Ewell Nolle Bldg., Austin, Texas .. 1909
SVENSON, CARL I., Associate Professor of Heat Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1937
SWAIM, VERNE F., Professor and Head, Dept. of Physics, Bradley Polytechnic Institute, Peoria, Ill. 1919
SWANSON, HARRY A., Assistant Professor of Civil Engineering, North Dakota Agricultural College, Fargo, N. D. 1942
SWARTZ, BLAIR K., Supervisor of Personnel Research, Detroit Edison Company, Detroit, Mich. 1931
SWEENEY, O. R., Professor and Head, Dept. of Chemical Engineering, Iowa State College, Ames, Iowa 1934
SWEETSER, E. O., Professor of Civil Engineering, Washington University, St. Louis, Mo. 1910
SWEIGERT, RAY L., Professor of Mechanical Engineering, Director, General Engineering, Georgia School of Technology, Atlanta, Ga. (*Member of Council, 1936–39.*) 1929
SWENSON, GEORGE W., Professor and Head, Department of Electrical Engineering, Michigan College of Mining and Technology, Houghton, Mich. In military service 1928
SWETT, GEORGE W., Professor of Machine Design, Massachusetts Institute of Technology, Cambridge, Mass. 1933
SWIFT, ROY E., Instructor in Mechanical Engineering, University of Alaska, College, Alaska 1940
SWINEFORD, CHARLES R., Associate Professor of Machine Design, Illinois Institute of Technology, Chicago, Ill. 1935
SWITZER, F. G., Senior Engineer, Mechanical Board of Water Supply, 346 Broadway, New York City 1934
SYPHERD, W. O., Professor of English, University of Delaware, Newark, Del. 1914
TAFT, THEODORE H., Associate Professor of Heat Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1926
TAGGART, ARTHUR F., Professor of Mineral Dressing, Columbia University, New York City 1938
TAIT, RALPH S., Associate Professor of Mechanical Engineering, University of Kansas, Lawrence, Kans. 1921
TALLMAN, W. D., Professor of Mathematics, Montana State College, Bozeman, Mont. 1932
TALMAGE, S. B., Professor and Head, Dept. of Geology and Mineralogy, New Mexico School of Mines, Socorro, N. M. 1932
T'ANG, CHEN-HSU, Engineer and Liaison Secretary, Universal Trading Corp, New York, N. Y. 1941
TANG, KWAN Y., Associate Professor of Electrical Engineering, The Ohio State University, Columbus, Ohio 1928
TAPPAN, FRANK G., Director, School of Electrical Engineering, University of Oklahoma, Norman, Okla. 1921
TAPY, RALPH W., Head, Dept. of Electrical Engineering, University of New Mexico, Albuquerque, N. M. 1934

TARPLEY, H. I., Associate Professor of Electrical Engineering, The Pennsylvania State College, State College, Pa. 1934
TATNALL, F. G., Manager, Testing Equipment Division, Baldwin-Southwark Corp., Paschall P. O., Philadelphia, Pa. 1935
TAYLOR, ALBERT L., Dean, School of Mines and Engineering, Head, E. E. Dept., University of Utah, Salt Lake City, Utah 1938
TAYLOR, ALTON D., Associate Professor and Acting Head, Dept. of Civil Engineering, Norwich University, Northfield, Vt. 1936
TAYLOR, BERNARD P., Assistant to the President, Illinois Institute of Technology, Chicago, Ill. 1942
TAYLOR, DELOS C., Assistant Professor of Applied Mechanics, Kansas State College, Manhattan, Kansas. In military service 1932
TAYLOR, DONALD W., Assistant Professor of Soil Mechanics, Massachusetts Institute of Technology, Cambridge, Mass. 1937
TAYLOR, E., Professor of Engineering Mechanics, Pomona College, Claremont, Calif. 1927
TAYLOR, FRANCIS M., Assistant Professor of Chemical Engineering, Tulane University, New Orleans, La. 1939
TAYLOR, FRANK M., Instructor in Civil Engineering, University of Maine, Orono, Me. 1941
TAYLOR, WALTER A., Assistant Professor of Architecture, Syracuse University, Syracuse, N. Y. 1941
TAYLOR, W. C., Associate Professor of Civil Engineering, Union Universersity, Schenectady, N. Y. 1913
TAYLOR, WILLIAM H., Professor of Drawing and Surveying, Supervisor, E. S. M. D. T., University of Alabama, University, Ala. 1942
TEA, PETER L., Assistant Professor of Drafting, College of the City of New York, New York City 1935
TEARE, B. RICHARD, JR., Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1933
TEICHMANN, F. K., Professor and Chairman, Dept. of Aeronautical Engineering, New York University, New York, N. Y. 1930
TELLE, LEONDERT, Mechanical Engineer, Shell Univ., 22 Negropont, Curacao, D. W. I. 1942
TEMPLE, EDWARD H., Master of Drafting, Mechanic Arts High School, Boston, Mass. 1938
TENNEY, EDWARD A., Associate Professor of English, Cornell University, Ithaca, N. Y. 1939
TERRELL, DANIEL V., Assistant Dean of Engineering, University of Kentucky, Lexington, Ky. 1917
TERWILLIGER, C. V. O., Professor and Head, Dept. of Electrical Engineering, Post Graduate School, U. S. Naval Academy, Annapolis, Md. 1924
THATCHER, CHARLES G., Associate Professor of Mechanical Engineering, Swarthmore College, Swarthmore, Pa. 1929
THATCHER, ROMEYN Y., Associate Professor of Civil Engineering, Cornell University, Ithaca, N. Y. 1934
THAYER, HORACE R., Assistant Professor of Engineering Drawing, Pennsylvania State College, State College, Pa. 1930
THEISS, E. S., Instructor in Mechanical Engineering, Duke University, Durham, N. C. 1939
THEOBALD, JOHN J., Assistant Professor of Civil Engineering, College of the City of New York, New York City 1940
THEROUX, FRANK R., Associate Professor of Civil Engineering, Michigan State College, East Lansing, Mich. 1938

THOM, GEORGE B., Assistant Professor of Mechanical Engineering, Swarthmore College, Swarthmore, Pa. 1935
THOMAN, WM. H., Associate Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1940
THOMAS, ALBERT L., Professor of Engineering Drawing, Alabama Polytechnic Institute, Auburn, Ala. 1928
THOMAS, CHARLES F., Professor of Mathematics, Case School of Applied Science, Cleveland, O. 1909
THOMAS, D. BOYD, Instructor in Apprentice School, Newport News Shipbuilding & Dry Dock Co., Newport News, Va. 1938
THOMAS, EVAN, Professor of Mechanics and Mathematics, Emeritus, University of Vermont, 38 Winans St., East Orange, N. J. 1908
THOMAS, FRANKLIN, Professor of Civil Engineering, Chairman, Engineering Division, California Institute of Technology, Pasadena, Calif. .. 1914
THOMAS, FREDERICK H., Associate Professor of Mechanical Engineering, University of Tennessee, Knoxville, Tenn. 1926
THOMAS, GEO. B., Personnel Director, Bell Telephone Laboratories, Inc., 463 West St., New York, N. Y. 1911
THOMAS, GILBERT D., Assistant Professor of Industrial Engineering, The Pennsylvania State College, State College, Pa. 1937
THOMAS, HAROLD A., Professor of Civil Engineering, Acting Head, Dept. of Mechanics, Carnegie Institute of Technology, Pittsburgh, Pa. ... 1913
THOMAS, LUTHER W., Instructor in Engineering Drawing, Purdue University, Lafayette, Ind. 1939
THOMAS, M. A., Professor and Head, Dept. of Electrical Engineering, New Mexico College of A. & M., State College, N. M. 1934
THOMAS, WILLIAM A., Electrical Engineer, E. I. du Pont de Nemours Co., Inc., Wilmington, Del. 1938
THOMPSON, H. LOREN, Assistant Professor of Civil Engineering, Northwestern University, Evanston, Ill. 1939
THOMPSON, J. GEORGE H., Assistant Professor of Mechanical Engineering, Texas A. & M. College, College Station, Texas 1938
THOMPSON, JAMES S., Executive Vice President, McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. (*Treasurer, 1913–; Member of Council, 1938–.*) 1911
THOMPSON, JAMES S., Professor and Chairman, Dept. of Physics, Illinois Institute of Technology, Chicago, Ill. 1935
THOMPSON, JOSEPH T., Professor of Civil Engineering, The Johns Hopkins University, Baltimore, Md. **In military service** 1941
THOMPSON, KARL O., Professor of English, Case School of Applied Science, Cleveland, O. 1919
THOMPSON, M. J., Professor and Head, Dept. of Aeronautics, The University of Texas, Austin, Texas 1934
THOMPSON, SOPHUS, Professor of Civil Engineering, Southern Methodist University, Dallas, Texas 1936
THOMSON, FRANCIS A., President, Montana School of Mines, Butte, Mont. 1927
THORNBURG, MARTIN L., Professor and Head, Dept. of Mechanical Engineering, University of Arizona, Tucson, Ariz. 1925
THORNTON, JESSE E., Associate Professor of English, University of Michigan, Ann Arbor, Mich. 1936
THOROGOOD, BRACKETT K., Director, Franklin Technical Institute, Boston, Mass. 1940
THRESHER, B. ALDEN, Director of Admissions, Associate Professor of Economics, Massachusetts Institute of Technology, Cambridge, Mass. .. 1935

THUESEN, H. G., Professor and Head, Dept. of Industrial Engineering, Oklahoma A. and M. College, Stillwater, Okla. 1926
TIBBALS, C. AUSTIN, Dean, Undergraduate College and Professor of Chemistry, Illinois Institute of Technology, Chicago, Ill. 1935
TICE, LAWRENCE W., Manager, College Dept., International Textbook Co., Scranton, Pa. 1936
TILGHMAN, HARRISON, Councillor-at-Law, Foxly Hall, Easton, Md. 1919
TILLES, ABE, Assistant Professor of Electrical Engineering, University of California, Berkeley, Calif. 1937
TIMBIE, WILLIAM H., Professor of Electrical Engineering and Industrial Practice, Massachusetts Institute of Technology, Cambridge, Mass. (*Member of Council, 1929–32.*) 1908
TIMBY, ELMER K., Associate Professor of Civil Engineering, Princeton University, Princeton, N. J. 1929
TIMOSHENKO, GREGORY S., Associate Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. 1939
TIMOSHENKO, STEPHEN, Professor of Theoretical and Applied Mechanics, Stanford University, Stanford University, Calif. **Twelfth Recipient, Lamme Medal (1939)** 1927
TINGLEY, FREEMAN T., Professor of Electrical Engineering, Clemson College, Clemson College, S. C. 1927
TODD, M. E., Assistant Professor of Electric Power Engineering, University of Minnesota, Minneapolis, Minn. 1913
TODD, MARION W., Associate Professor of Topographical Engineering, Purdue University, Lafayette, Ind. 1926
TOMLINSON, GEORGE E., Senior Office Engineer, Tennessee Valley Authority; Lecturer in Civil Engineering, University of Tennessee, Knoxville, Tenn. **In military service** 1933
TOMPKINS, FREDERICK N., Associate Professor of Electrical Engineering, Brown University, Providence, R. I. 1922
TONKIN, JOHN C., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. 1935
TOOLE, C. E., Instructor in Physical Elements, Pratt Institute, Brooklyn, N. Y. 1931
TOPORECK, EDWARD R., Instructor in Mechanical Drawing, Wentworth Institute, Boston, Mass. 1939
TOPPING, ALANSON N., Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1931
TORGERSEN, HAROLD, Assistant Professor of Electrical Engineering, New York University, New York City. **In military service** 1935
TORRANCE, CHARLES C., Assistant Professor of Mathematics, Case School of Applied Science, Cleveland, Ohio 1941
TOWLE, GEORGE W., Associate Professor of Coördination, Northeastern University, Boston, Mass. 1939
TOWLE, NORMAN L., Professor in charge of Electrical Engineering Dept., Cooper Union, New York City 1925
TOWNSEND, ARTHUR L., Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1933
TOWNSEND, CLARENCE E., Professor and Head, Dept. of Engineering Drawing, Cornell University, Ithaca, N. Y. 1930
TOZER, ELIOT F., Professor and Head, Dept. of Drawing, Northeastern University, Boston, Mass. 1927
TRACY, GORDON F., Associate Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1928

TRACY, JOHN C., Emeritus Professor of Civil Engineering, Yale University, 345 Winthrop Ave., New Haven, Conn. (*Member of Council, 1912–5; 1920–3.*) 1907

TRACY, STEPHEN J., Assistant Professor of Mechanical Engineering, College of the City of New York, New York City 1930

TRATHEN, ROLAND H., Assistant Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1935

TRENT, CLARENCE E., Assistant Professor and Mgr., Bluefield Branch of Virginia Polytechnic Institute, Bluefield, W. Va. 1938

TREZISE, FRED W., Professor of Engineering, Lawrence College, Appleton, Wis. (Box 195, Norris, Tenn.) 1939

TRIEST, RUDOLPH M., Manager Editorial Department, John Wiley and Sons, Inc., 440 Fourth Avenue, New York City 1924

TRIGGER, KENNETH J., Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. 1936

TRIPP, WILSON, Associate Professor of Mechanical Engineering, Kansas State College, Manhattan, Kansas 1937

TRIVELY, ILO A., Assistant Professor of Civil Engineering, Clemson College, Clemson, S. C. 1942

TROTTER, RICHARD A., Associate Professor of Experimental Engineering, Georgia School of Technology, Atlanta, Ga. 1929

TROWBRIDGE, DOUGLAS S., Professor of Civil Engineering, New York University, New York City 1924

TROXELL, GEORGE E., Associate Professor of Civil Engineering, University of California, Berkeley, Calif. 1940

TRUEBLOOD, RALPH B., Professor of Engineering Shop Practice, Purdue University, Lafayette, Ind. 1922

TRUEBLOOD, RICHARD O., Instructor in Mechanical and Electrical Engineering, University of Wyoming, Laramie, Wyo. 1931

TRUETTNER, W. I., Associate Professor of Mechanical Engineering, A. & M. College of Texas, College Station, Texas 1938

TRUMPLER, PAUL R., Development Engineer, M. W. Kellogg Co., New York City 1940

TSCHEBOTARIOFF, GREGORY P., Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J. 1937

TUCKER, CARLTON E., Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. (*Member of Council, 1942–45.*) 1922

TUCKER, LEROY, Assistant Professor of Mechanics, The Ohio State University, Columbus, Ohio 1927

TUCKER, SAMUEL M., Professor of English, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1937

TUDBURY, CHESTER W., Head, Department of Mathematics, Wentworth Institute, Boston, Mass. 1921

TURNBULL, W. D., Junior Dean, College of Engineering, The Ohio State University, Columbus, Ohio 1917

TURNEAURE, F. E., Dean Emeritus, University of Wisconsin, 116 No. Prospect Ave., Madison, Wis. (*President, 1908–9; Member of Council since 1903; Member, Board of Investigation and Coördination, 1925–33.*) **Tenth Recipient, Lamme Medal (1937)** 1894

TURNER, ADLAI S., Professor of Civil Engineering, Arkansas Polytechnic College, Russellville, Ark. **In military service** 1940

TURNER, FRANCIS M., Vice President, The Reinhold Publishing Co., 330 West 42nd St., New York City 1942

TURNER, HERBERT M., Associate Professor of Electrical Engineering, Yale University, New Haven, Conn. 1929
TURNER, RICHARD C., JR., Dept. of Electrical Engineering, U. S. Naval Academy, Annapolis, Md. **In military service** 1938
TURNER, WILLIAM W., Head, Dept. of Engineering Drawing, University of Notre Dame, Notre Dame, Ind. 1939
TUTHILL, ARTHUR F., Instructor in Mechanical Engineering, Cooper Union, New York City 1939
TUTHILL, JOHN K., Associate Professor of Railway Electrical Engineering, University of Illinois, Urbana, Ill. 1922
TUTT, CHARLES L., Assistant Professor of Mechanical Engineering, Princeton University, Princeton, N. J. 1941
TUVE, GEORGE L., Professor of Heat-Power Engineering, Case School of Applied Science, Cleveland, Ohio 1925
TWENEY, G. H., Acting Director, Dept. of Aeronautics, University of Detroit, Detroit, Mich. 1941
TWOGOOD, A. J., Instructor in Engineering, Riverside Junior College, Riverside, Calif. 1933
TYKOCINER, JOSEPH T., Research Professor of Electrical Engineering, University of Illinois, Urbana, Ill. 1929
TYLER, EDWARD J., Associate Manager, College Department, Harper & Brothers, Publishers, 49 E. 33rd St., New York City 1940
TYRRELL, CECIL C., Associate Professor of Mechanical Engineering, Rutgers University, New Brunswick, N. J. 1934
UHLER, EUGENE H., Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. 1936
UICKER, JOHN J., Instructor in Mechanical Engineering, University of Detroit, Detroit, Mich. 1933
UNDERHILL, JAMES, Associate Professor of Mining, Colorado School of Mines, Golden, Colo. 1921
UNDERWOOD, P. H., Professor of Surveying, Cornell University, Ithaca, N. Y. 1922
UPDEGROVE, HENRY T., JR., Instructor in Mechanical Engineering, College of the City of New York, New York City 1938
UPP, CLARENCE R., Associate Professor of Mechanical Engineering, University of Akron, Akron, Ohio 1928
UPTHEGROVE, CLAIR, Professor of Metallurgical Engineering, University of Michigan, Ann Arbor, Mich. 1940
UREN, LESTER C., Professor of Petroleum Engineering, University of California, Berkeley, Calif. 1939
VACHA, FRED, Development Engineer, The Holtzer Cabot Electric Co., Boston, Mass. 1932
VAGTBORG, HAROLD A., Director, Armour Research Foundation; Institute of Gas Technology, Illinois Institute of Technology, Chicago, Ill. .. 1936
VAIL, CHARLES R., Instructor in Electrical Engineering, Duke University, Durham, N. C. 1940
VAIL, ROBERT P., Head of Mechanical Engineering, Pantex Ordnance Plant, Amarillo, Texas 1938
VAILE, ROBERT B., Assistant Professor of Electrical Engineering, University of Missouri, Columbia, Mo. 1937
VALADE, ERNEST A., Associate Professor of Electrical Engineering, Catholic University of America, Washington, D. C. 1936
VANCE, HAROLD, Professor and Head, Dept. of Petroleum Engineering, A. & M. College of Texas, College Station, Texas 1937

VANDEGRIFT, CLARENCE G., Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa. 1938
VAN DEN BROEK, J. A., Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. 1924
VANDER VELDE, THEODORE L., Assistant Professor of Sanitary Engineering, Missouri School of Mines, Rolla, Mo. 1938
VAN DRIEST, EDWARD R., Associate Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. 1942
VAN DYKE, JAMES R., Acting Head, Dept. of Mechanical Engineering, University of Nevada, Reno, Nev. 1941
VAN HAGAN, L. F., Professor and Chairman, Dept. of Civil Engineering, University of Wisconsin, Madison, Wis. 1912
VAN HOUTEN, ROBERT W., Assistant Dean, Newark College of Engineering, Newark, N. J. 1933
VAN LEER, BLAKE R., Dean, College of Engineering, North Carolina State College, Raleigh, N. C. (*Member of Council, 1933–36.*) **In military service** 1923
VAN NOTE, WILLIAM G., Associate Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. 1936
VAN ORNUM, J. L., Emeritus Professor of Civil Engineering, Washington University, 126 Linden Ave., Clayton, Mo. (*Member of Council, 1902–5.*) 1895
VAN PELT, JOHN R., Technical Director, Museum of Science and Industry, 5740 Kimbark Ave., Chicago, Ill. 1936
VAN WAMBECK, STANLEY H., Assistant Professor of Electrical Engineering, Washington University, St. Louis, Mo. 1938
VAN WERT, LELAND R., Chief, Metallurgical Division, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. 1941
VAN WINKLE, EDWARD H., Professor of Business Statistics, Rensselear Polytechnic Institute, Troy, N. Y. 1935
VAUGHAN, JOSEPH L., Associate Professor and Head, School of English, University of Virginia, University, Va. 1930
VAUGHAN, L. L., Professor and Head, Dept. of Mechanical Engineering, Acting Dean, North Carolina State College, Raleigh, N. C. 1912
VAWTER, JAMISON, Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1926
VEAL, C. B., Manager, Cooperative Research Council, 30 Rockefeller Plaza, New York City 1910
VEIT, ROBERT C., Assistant Professor of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1939
VELZ, CLARENCE J., Professor of Sanitary Engineering, Head, Dept. of Civil Engineering, Manhattan College, New York City 1938
VENN, ROLLO E., Assistant Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
VENNARD, JOHN K., Assistant Professor of Fluid Mechanics, New York University, New York City 1935
VENNUM, ROBERT R., 2605 Franklin St., Wilmington, Del. 1940
VERPLANCK, DENNISTOUN W., Assistant Professor of Electrical Engineering, Yale University, New Haven, Conn. (Naval Ord. Lab., Washington, D. C.) 1937
VETTER, HARRY F., Teacher of Applied Mathematics, Secondary Schools, N. Y. C.; 14409–97 Ave., Jamaica, N. Y. 1932
VIDOSIC, JOSEPH P., Assistant Professor of Engineering Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. **In military service** 1938

VIERCK, CHARLES J., Associate Professor of Engineering Drawing, The Ohio State University, Columbus, Ohio 1942
VIERCK, ROBERT K., Assistant Engineer, Federal Power Commission, 902 Hurley-Wright Bldg., Washington, D. C. **In military service** 1937
VILBRANDT, FRANK C., Professor and Head, Dept. of Chemical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1931
VILLEMONTE, JAMES R., Assistant Professor of Civil Engineering, The Pennsylvania State College, State College, Pa. 1941
VINCENT, EDWARD T., Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1940
VITTUCCI, ROCCO V., Associate Marine Engineer, Bureau of Ships, U. S. Navy Dept., Washington, D. C. 1938
VIVELL, ALLEN E., Assistant Professor of Electrical Engineering, Princeton University, Princeton, N. J. 1937
VIVIAN, ROBERT E., Dean of Engineering, University of Southern California, Los Angeles, Calif. 1937
VON URFF, HARRISON A., Chief Bibliographer, Engineering Societies Library, 29 West 39th St., New York City 1942
VOORHIES, M. B., Professor of Electrical Engineering, Assistant to the Dean, Louisiana State University, University, La. 1935
VOPAT, WM. A., Assistant Professor of Mechanical Engineering, Cooper Union, New York City. (150 Park Blvd., Malverne, N. Y.) 1932
VOSE, F. H., Professor of Mechanical Engineering, Case School of Applied Science, Cleveland, O. 1907
VOSS, WALTER C., Professor and Head of Building Construction, Massachusetts Institute of Technology, Cambridge, Mass. 1932
VOTH, JOHN J., Assistant Professor of Industrial Arts, Bethel College, North Newton, Kansas 1934
WABNITZ, W. S., Assistant Professor of English, University of Cincinnati, Cincinnati, Ohio 1932
WADE, FRANK H., Assistant Professor of Mechanics, Illinois Institute of Technology, Chicago, Ill. 1927
WAGNER, EDWARD F., Instructor in Chemistry, Illinois Institute of Technology, Chicago, Ill. 1942
WAGNER, HERMAN A., Consulting Mining and Metallurgical Engineer, 8 So. Michigan Ave., Chicago, Ill. 1907
WAGNER, WARREN O., Personnel Manager, Contractors, Pacific Naval Air Bases, P. O. Box 2459, Honolulu, T. H. 1939
WAIDELICH, DONALD L., Assistant Professor of Electrical Engineering, University of Missouri, Columbia, Mo. 1939
WAKEFIELD, ERNEST H., Instructor in Electrical Engineering, University of Tennessee, Knoxville, Tenn. 1941
WALES, ROYAL L., Professor of Mechanical Engineering and Dean of Engineering, Rhode Island State College, Kingston, R. I. 1914
WALKER, CHARLES A., Instructor in Chemical Engineering, Yale University, New Haven, Conn. 1942
WALKER, CHAS. L., Professor of Sanitary Engineering, College of Engineering, Cornell University, Ithaca, N. Y. 1910
WALKER, ERIC A., Special Research Associate, Harvard University, Cambridge, Mass. 1938
WALKER, HARRY B., Professor of Agricultural Engineering, University of California, University Farm, Davis, Calif. (*Member of Council, 1933–36.*) 1921
WALKER, HARRY N., Director of Research, The B. G. Corp., New York City 1931

WALKER, LEONARD D., Assistant Professor of General Engineering Drawing, University of Illinois, Urbana, Ill. 1928
WALKER, S. BRANCH, Lt. Inf., U. S. Army, Huntsville Arsenal, Ala. ... 1936
WALKUP, JOSEPH K., Professor and Head, Dept. General Engineering, Iowa State College, Ames, Iowa 1941
WALLACE, LAWRENCE W., Vice President, Trundle Engineering Co., Cleveland, Ohio 1924
WALLIS, CLIFFORD M., Associate Professor of Electrical Engineering, University of Missouri, Columbia, Mo. In military service 1935
WALLS, JOHN A., President, Pennsylvania Water & Power Co., 1611 Lexington Bldg., Baltimore, Md. 1932
WALSH, FRANK W., Walsh's Visual Aids Co., P. O. Box 432, Oshkosh, Wis. 1928
WALSH, HAROLD V., Assistant Professor of Drafting, College of the City of New York, New York City 1940
WALTER, HAROLD E., Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. 1936
WALTERS, JACK E., Vice President, Personnel and Labor Relations, Revere Copper & Brass Co., Rome, N. Y. 1926
WALTERS, RAYMOND, President, University of Cincinnati, Cincinnati, Ohio 1935
WALTHER, CARL H., Assistant Professor of Civil Engineering, George Washington University, Washington, D. C. 1942
WALTON, SYLVAN B., Associate Professor of Mechanical Engineering, University of Kentucky, Lexington, Ky. 1939
WALTON, T. O., President, A. & M. College of Texas, College Station, Texas 1937
WANDMACHER, CORNELIUS, Assistant Professor of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1939
WARD, HENRY T., Associate Professor of Chemical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1937
WARD, ROBERT P., Associate Professor of Electrical Engineering, A. & M. College of Texas, College Station, Texas 1937
WARD, SAMUEL, Professor and Head, Dept. of Mechanics and Materials, Fenn College, Cleveland, O. 1917
WARDLE, RALPH M., Instructor in English, Cornell University, Ithaca, N. Y. 1941
WARE, LAWRENCE A., Associate Professor of Electrical Engineering, State University of Iowa, Iowa City, Iowa 1939
WAREING, JOHN F., Lt. U. S. N. R., Phila. Navy Yard, Training Officer, Philadelphia, Pa. 1939
WARNER, FRANK M., Professor of Engineering Drawing, University of Washington, Seattle, Wash. 1927
WARNER, HARRY O., Professor and Head, Dept. of Electrical Engineering, University of Detroit, Detroit, Mich. 1926
WARNER, ROBERT W., Professor and Chairman, Dept. of Electrical Engineering, University of Texas, Austin, Texas 1930
WARNER, RUSSELL G., United Illuminating Co., New Haven, Conn. 1924
WARNOCK, WALTER G., Assistant Professor of Mathematics, University of Alabama, Tuscaloosa, Ala. 1936
WARREN, A. JOEL, Instructor in Mechanical Engineering, Brown University, Providence, R. I. 1941
WATANABE, KENICHI, Instructor in Mathematics and Engineering, University of Hawaii, Honolulu, T. H. 1940
WATERFALL, HARRY W., Professor and Head, Dept. of Mechanical Engineering, Louisiana State University, University, La. 1937

WATERMAN, EARLE L., Professor of Sanitary Engineering, University of Iowa, Iowa City, Iowa 1923

WATERMAN, HERBERT, Assistant Professor and Acting Head, Dept. of Chemical Engineering, University of Southern California, Los Angeles, Calif. 1941

WATERS, EVERETT O., Associate Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1914

WATERS, JAMES S., Professor of Electrical Engineering, Rice Institute, Houston, Texas. **In military service** 1931

WATSON, ARTHUR E., Emeritus Associate Professor of Electrical Engineering, Brown University, Providence, R. I. 1924

WATSON, CLARENCE E., Assistant Professor of Industrial Relations, Northwestern University, Evanston, Ill. 1942

WATSON, HARRY D., Professor and Head, Dept. of Mechanical Engineering, University of Maine, Orono, Me. 1926

WATSON, HARRY J., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1940

WATSON, JAMES W., Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. 1910

WATSON, WALTER S., Assistant Professor of Psychology, Director of Admissions and Student Relations, Cooper Union, New York City 1939

WATT, DAVID M., Head, Employment Dept., Procter & Gamble Co., Ivorydale, Ohio 1940

WATTS, CALVIN T., Assistant Professor of Civil Engineering, Louisiana Polytechnic Institute, Ruston, La. 1941

WATWOOD, VERNON B., Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. 1941

WEAVER, FREDERIC N., Professor of Civil Engineering, Tufts College, Medford, Mass. 1924

WEBB, EARL C., Extension Lecturer in Drawing, Purdue University; South Bend, Ind. 1937

WEBBER, H. A., Professor of Chemical Engineering, Iowa State College, Ames, Iowa 1939

WEBER, ANDREW R., Professor of Mechanical Engineering, University of Dayton, Dayton, Ohio 1935

WEBER, ERNST, Graduate Professor and Head, Dept. of Graduate Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1935

WEBER, HOMER S., Professor of Engineering Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. 1935

WEBSTER, FRED N., Instructor in Mechanical Engineering, Tufts College, Medford, Mass. 1941

WEBSTER, JAMES C., Teacher, Armstrong High School, Washington, D. C. 1938

WEED, JOHN M., Associate Professor and Editor, Engineering Experiment Station, The Ohio State University, Columbus, Ohio 1923

WEEDEN, HARMAR A., Instructor in Civil Engineering, Bucknell University, Lewisburg, Pa. 1941

WEEMS, PHILIP V., Lt. Comdr. U. S. Navy, Randall House, Annapolis, Md. 1942

WEIBEL, EMIL E., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. 1936

WEIDLEIN, EDWARD R., Director, Mellon Institute of Industrial Research, Pittsburgh, Pa. 1936

WEIL, JOSEPH, Dean, College of Engineering, Director, Engineering Experiment Station, University of Florida, Gainesville, Fla. (*Member of Council, 1942–45.*) 1923

WEIL, ROBERT T., Assistant Professor of Electrical Engineering, Manhattan College, New York City 1936

WEILAND, W. F., Associate Professor of Mechanical Engineering, University of Nebraska, Lincoln, Nebr. 1921

WEINBACH, M. P., Professor of Electrical Engineering, University of Missouri, Columbia, Mo. 1915

WEIR, JOHN J., Instructor, Sperry Gyroscope Co., 189 Hutton St., Jersey City, N. J. 1942

WEISER, HARRY B., Dean and Professor of Chemistry, Rice Institute, Houston, Texas 1938

WEISS, HERBERT A., Professor of Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. 1930

WEISS, JOSEPH R., Instructor in Mechanical Engineering, College of the City of New York, New York City. **In military service** 1940

WELCH, ERNEST R., Associate Professor and Head, Dept. of Electrical Engineering, Howard University, Washington, D. C. **In military service** 1938

WELCH, FREDERIC W., Assistant Professor of Civil Engineering, State College of Washington, Pullman, Wash. 1921

WELCH, HERBERT E., Professor of Practical Science, Stockton Junior College, Stockton, Calif. 1942

WELKE, RUDOLPH A., Instructor in Industrial Management, Pratt Institute, Brooklyn, N. Y. 1942

WELLMAN, BERNARD L., Assistant Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1937

WELLS, MELVILLE B., Professor and Head, Dept. of Civil Engineering, Illinois Institute of Technology, Chicago, Ill. 1925

WENDT, KURT F., Associate Professor of Mechanics, University of Wisconsin, Madison, Wis. 1927

WENDT, ROBERT E., Instructor in Foundry Practice, Purdue University, Lafayette, Ind. 1922

WENDT, WYLIE B., Professor of Civil Engineering, Speed Scientific School, University of Louisville, Louisville, Ky. 1908

WERWATH, KARL O., Registrar, Milwaukee School of Engineering, Milwaukee, Wis. 1938

WESKE, JOHN R., Professor of Aerodynamics, Case School of Applied Science, Cleveland, Ohio 1937

WESSMAN, HAROLD E., Professor of Structural Engineering, Chairman, Dept. of Civil Engineering, New York University, New York City .. 1934

WESTERGAARD, HARALD M., Dean, Graduate School of Engineering; Gordon MacKay Professor of Civil Engineering, Harvard University, Cambridge, Mass. 1937

WETZEL, IRWIN T., Assistant Professor of Mechanical Engineering, University of Iowa, Iowa City, Iowa 1942

WEYSSER, JOHN L. G., Assistant Professor of Mining Engineering, University of Illinois, Urbana, Ill. 1940

WHARTON, JAMES R., Associate Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. 1919

WHEATON, HERBERT H., Professor of Mathematics and Engineering, Fresno State College, Fresno, Calif. 1936

WHEELER, FRED B., Professor of Practical Mechanics, North Carolina State College, Raleigh, N. C. 1933
WHEELER, NATHANIEL E., Professor of Physics, Colby College, Box 135, R. F. 4, Manchester, N. H. 1921
WHELAN, DANIEL E., JR., Professor of Civil Engineering, Dean, College of Science, Loyola University, Los Angeles, Calif. 1931
WHENMAN, JOHN H., Assistant Professor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1930
WHETSTONE, GEORGE A., Instructor in Mathematics and Engineering, Amarillo College, Amarillo, Texas 1941
WHIPPLE, CLYDE C., Professor of Electrical Engineering, Brooklyn Polytechnic Institute, Brooklyn, N. Y. 1924
WHIPPLE, GEORGE F., Educational Director, Ponder Institute, 50 Beacon Street, Boston, Mass. 1937
WHIPPLE, WILLIAM, Professor of Steam Engineering, Louisiana State University, University, La. 1940
WHISLER, BENJAMIN A., Associate Professor of Civil Engineering, Iowa State College, Ames, Iowa. **In military service** 1939
WHITAKER, MARTIN D., Assistant Professor and Acting Chairman, Dept. of Physics, New York University, New York City 1938
WHITE, ALBERT E., Director, Engineering Research, Professor of Metallurgical Engineering, University of Michigan, Ann Arbor, Mich. .. 1941
WHITE, ALFRED H., Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich. (*President, 1941–42; Member of Council, 1937–40; 1941–.*) 1920
WHITE, BENNETT S., Assistant Professor of Machine Design and Drawing, West Virginia University, Morgantown, W. Va. 1926
WHITE, G. EDWIN, Assistant Professor of Chemical Engineering, College of the City of New York, New York City 1940
WHITE, HALL B., Assistant Professor of Agricultural Engineering, University of Minnesota, St. Paul, Minn. 1925
WHITE, HAROLD V., Assistant Professor and Acting Head, Dept. of Metallurgy, Virginia Polytechnic Institute, Blacksburg, Va. 1937
WHITE, JOHN, Professor Retired, Rose Polytechnic Institute, 2235 No. 10 St., Terre Haute, Ind. 1929
WHITE, JOHN R., Instructor in Civil Engineering, College of the City of New York, New York City 1939
WHITE, KENNETH R., Instructor in Civil Engineering, University of Colorado, Boulder, Colo. 1942
WHITE, LEON V., Professor of Civil Engineering, Kansas State College, Manhattan, Kans. 1923
WHITE, MERIT P., Assistant Professor of Civil Engineering, Illinois Institute of Technology, Chicago, Ill. **In military service** 1941
WHITE, MYRA, Librarian, Northeastern University, Boston, Mass. 1941
WHITE, ROY A., Head, Engineering Dept., The Grand Rapids Junior College, Grand Rapids, Mich. 1925
WHITE, WALTER T., Project Engineer, Sperry Gyroscope Co., Inc., Garden City, N. Y. 1939
WHITE, WILLIAM C., Dean of Engineering, Northeastern University, Boston, Mass. 1926
WHITEHEAD, L. W., Associate Professor of Civil Engineering, The Pennsylvania State College, State College, Pa. 1918
WHITFORD, ROBERT H., Physics-Chemistry Librarian, College of the City of New York, New York City 1942

WHITMER, ANNE B., Instructor in English, The Ohio State University, Columbus, Ohio 1942
WHITTAKER, ALBERT E., Assistant Professor of Mechanical Engineering, Northeastern University, Boston, Mass. 1939
WHITTEMORE, JOHN W., Professor and Head, Dept. of Ceramic Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1937
WHITWELL, JOHN C., Assistant Professor and Acting Chairman, Dept. of Chemical Engineering, Princeton University, Princeton, N. J. 1936
WICKENDEN, WM. E., President, Case School of Applied Science, Cleveland, Ohio. (*President, 1933–34; Director of Investigations, 1923–29; Member of Council, 1924–7, 1933–.*) **Eighth Recipient, Lamme Medal (1935).** 1912
WICKERSHAM, ROBERT O., Assistant Professor of Aeronautical Engineering, The Pennsylvania State College, State College, Pa. **In military service** 1941
WIDDOP, ROBERT, Associate Professor of Industrial Engineering, Newark College of Engineering, Newark, N. J. 1932
WIDENER, BURTON M., Associate Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1935
WILBUR, JOHN B., Associate Professor of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1934
WILBUR, RALPH S., Professor and Chairman, Dept. of Mechanical Engineering, Duke University, Durham, N. C. 1933
WILCOX, CARL C., Head, Dept. of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. 1939
WILCOX, DONALD B., Associate Professor of Industrial Engineering, University of Alabama, University, Ala. **In military service** 1937
WILCOX, ELGIN R., Professor and Head, Dept. of General Engineering, University of Washington, Seattle, Wash. (*Member of Council, 1913–6.*) 1925
WILCOX, HOWARD G., Dean, School of Mines, Professor of Geology and Mining, University of Alaska, College, Alaska 1940
WILCOX, JAMES E., Head, Dept. of Engineering, Santa Rosa Junior College, Santa Rosa, Calif. 1934
WILDES, KARL L., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1926
WILEY, CARROLL C., Professor of Civil Engineering, University of Illinois, Urbana, Ill. 1936
WILEY, RALPH B., Professor and Head, School of Civil Engineering, Director, Materials Testing Lab., Purdue University, Lafayette, Ind. (*Member of Council, 1938–41.*) 1920
WILEY, W. BRADFORD, Secretary and Manager, Educational Dept., John Wiley & Sons, Inc., 440 Fourth Ave., New York City 1937
WILEY, W. O., Publisher of Scientific Books, Chairman of the Board, John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. (*Treasurer, 1907–42.*) **Honorary member** 1904
WILHELM, ERNEST J., Associate Professor of Chemical Engineering, University of Notre Name, Notre Dame, Ind. 1939
WILHELM, RICHARD H., Assistant Professor of Chemical Engineering, Princeton University, Princeton, N. J. 1936
WILKINSON, FORD L., Dean, Professor of Mechanical Engineering, Speed Scientific School, University of Louisville, Louisville, Ky. 1936
WILKINSON, GEORGE D., JR., Professor of Industrial Engineering, Newark College of Engineering, Newark, N. J. 1935

WILKINSON, ROGER I., Member Technical Staff, Bell Telephone Labs., 463 West St., New York City 1936
WILLARD, ARTHUR C., President, University of Illinois, Urbana, Ill. 1922
WILLEY, EARL C., Assistant Professor of Mechanical Engineering, Oregon State College, Corvallis, Ore. 1929
WILLIAMS, BERT B., Assistant Professor of Civil Engineering, The Citadel, Charleston, S. C. 1939
WILLIAMS, CLEMENT C., President, Lehigh University, Bethlehem, Pa. (*Member of Council, 1920–3, 1935–; Vice President, 1928–9; President, 1934–5.*) 1909
WILLIAMS, DAVID C., Instructor in Mechanics, The Ohio State University, Columbus, Ohio 1937
WILLIAMS, EVERARD M., Associate Engineer, Wright Field Army Aircraft Radio Lab., Dayton, Ohio 1939
WILLIAMS, EVERARD M., Instructor in Electrical Engineering, Pennsylvania State College, State College, Pa. 1939
WILLIAMS, FRANK H. M., Associate Professor of Mathematics, Drexel Institute of Technology, Philadelphia, Pa. 1937
WILLIAMS, GEORGE K., Senior Stress Analyst, Lockheed Aircraft Corp., Burbank, Calif. 1939
WILLIAMS, GORDON C., Associate Professor of Chemical Engineering, University of Louisville, Louisville, Ky. 1936
WILLIAMS, H. PAGE, Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1937
WILLIAMS, JOHN G., Assistant Professor of Engineering Drawing, Arkansas Polytechnic College, Russellville, Ark. 1940
WILLIAMS, J. P. J., Instructor in Civil Engineering, Cooper Union, New York City 1932
WILLIAMS, LA VERGNE E., Instructor in Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1942
WILLIAMS, ROBERT D., Associate in Mechanical Engineering, Battelle Memorial Institute, Columbus, Ohio 1941
WILLIAMSON, JAMES H., Associate Professor of Industrial Engineering, University of Tennessee, Knoxville, Tenn. 1942
WILLIG, WALTER L., Assistant Professor of Civil Engineering, College of the City of New York, New York City 1937
WILLIS, BEN S., Assistant Professor of Electrical Engineering, Iowa State College, Ames, Iowa 1929
WILLIS, CLODIUS H., Arthur Le Grand Doty Professor of Electrical Engineering, Princeton University, Princeton, N. J. (*Member of Council, 1933–36.*) 1936
WILLIS, PHILIP A., Senior Engineering Examiner, U. S. Civil Service Commission, 2912 Baker Drive, S.E., Washington, D. C. 1929
WILLISTON, ARTHUR L., 986 High Street, Dedham, Mass. (*Vice President, 1909–10; Secretary, 1907–9; Member of Council, 1900–3; 1905–8.*) 1897
WILLSON, F. G., Head, Department of Applied Electricity, Wentworth Institute, Boston, Mass. 1912
WILMORE, JOHN J., Dean, School of Engineering, and Professor of Mechanical Engineering, Alabama Polytechnic Institute, Auburn, Ala. (*Member of Council, 1928–31.*) 1894
WILSEY, EDWARD F., Associate Professor of Civil Engineering, Ohio University, Athens, Ohio 1939
WILSON, BERTON N., Professor and Head, Dept. of Drawing and Architecture, University of Arkansas, Fayetteville, Ark. 1933

WILSON, CURTIS L., Dean, Missouri School of Mines and Metallurgy, Rolla, Mo. 1941
WILSON, DAVID M., Professor of Civil Engineering, University of Southern California, Los Angeles, Calif. 1929
WILSON, EARL R., Assistant Professor of Mechanical Engineering, University of Akron, Akron, Ohio 1930
WILSON, ERNEST D., Head, Dept. of Chemical Engineering and Chemistry, Worcester Polytechnic Institute, Worcester, Mass. 1940
WILSON, FRANCIS W., President, Wilson Engineering Corp., College House Office, Harvard Square, Cambridge, Mass. 1931
WILSON, FREDERICK C., Chairman of Faculty, Professor of Civil and Sanitary Engineering, Clarkson College of Technology, Potsdam, N. Y. 1930
WILSON, H. A., Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1939
WILSON, JOHN W., Assistant Professor of Electrical Engineering, University of Florida, Gainesville, Fla. 1935
WILSON, LEE C., Instructor in English, Rhode Island State College, Kingston, R. I. 1940
WILSON, LEROY A., Professor and Chairman, Dept. of Mechanical Engineering, University of Wisconsin, Madison, Wis. 1923
WILSON, NORMAN E., Instructor in Electrical Engineering, University of Maine, Orono, Me. 1941
WILSON, WARREN E., Professor and Head, Dept. of Mechanics, Colorado School of Mines (1452 Scott Ave., Winnetka, Ill.) 1936
WILSON, WILBUR M., Research Professor of Structural Engineering, University of Illinois, Urbana, Ill. 1914
WILTSE, STANLEY B., Professor of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1935
WINDING, CHAS. C., Associate Professor of Chemical Engineering, Cornell University, Ithaca, N. Y. 1939
WINFREY, ROBLEY, Research Associate Professor of Civil Engineering, Iowa State College, Ames, Iowa. **In military service** 1940
WING, ALEXANDER H., JR., Instructor in Electrical Engineering, College of the City of New York, New York City 1935
WINGREN, ROY M., Associate Professor of Mechanical Engineering, Texas A. & M. College, College Station, Texas 1928
WINKLER, EDWIN W., Assistant Professor of Electrical Engineering, North Carolina State College, Raleigh, N. C. 1930
WINN, C. C., Dean of Engineering, Detroit Institute of Technology, Detroit, Mich. 1935
WINN, HARLAN F., Lieut., Civil Eng. Corps, U. S. Naval Res., Bureau of Naval Personnel, Washington, D. C. 1939
WINSLOW, A. E., Dean, Norwich University, Northfield, Vt. 1914
WINSTON, STANTON E., Associate Professor of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1928
WINTERKORN, HANS F., Associate Professor of Civil Engineering, University of Missouri, Columbia, Mo. 1940
WINTON, LOWELL S., Assistant Professor of Mathematics, North Carolina State College, Raleigh, N. C. 1939
WISCHMEYER, CARL, Vice President, Professor of Mechanical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. 1929
WISCHMEYER, CARL R., Acting Head, Dept. of Electrical Engineering, Rice Institute, Houston, Texas 1939
WISEMAN, EUGENE R., Associate Professor of Mechanics, Rensselaer Polytechnic Institute, Troy, N. Y. 1940

WISKOCIL, CLEMENT T., Professor of Civil Engineering, University of California, Berkeley, Calif. 1939
WISSMAN, ERNEST E., Industrial Engineer, Douglas Aircraft Co., Inc., El Segundo, Calif. 1942
WITHAM, R. L., Technical Employment Superintendent,, Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn, N. Y. 1914
WITHEY, M. O., Professor of Mechanics, University of Wisconsin, Madison, Wis. 1910
WITHROW, JAMES R., Professor and Head, Dept. of Chemical Engineering, Ohio State University, Columbus, O. 1907
WITMER, FRANCIS P., 95 Liberty St., New York City 1926
WITMER, LUTHER F., Associate Professor of Metallurgy, Lafayette College, Easton, Pa. 1931
WITTIG, FREDERICK E., Instructor in Shop Practice, Pratt Institute, Brooklyn, N. Y. 1941
WOHLENBERG, W. J., Sterling Professor of Mechanical Engineering, Yale University, New Haven, Conn. 1917
WOLF, HAROLD, Assistant Professor of Electrical Engineering, College of the City of New York, New York City 1942
WOLMAN, ABEL, Professor of Sanitary Engineering, The Johns Hopkins University, Baltimore, Md. 1940
WOLOWICZ, CHESTER H., Instructor in Mechanical Engineering, Northeastern University, Boston, Mass. 1939
WOOD, ARTHUR B., Associate Professor of Drawing and Machine Design, University of Tennessee, Knoxville, Tenn. 1938
WOOD, BEN D., Professor and Director of Collegiate Educational Research, Columbia University, New York, N. Y. 1931
WOOD, E. H., Professor of Mechanics of Engineering, Emeritus, Cornell University, Ithaca, N. Y. 1910
WOOD, ELLA L., Professor and Head, Dept. of Geography and Languages, Michigan College of M. & T., Houghton, Mich. 1935
WOOD, FRANCIS P., Instructor in Electrical Engineering, Gonzaga University, Spokane, Wash. 1941
WOOD, HENRY A., Research Mathematician, Vought-Sikorsky Aircraft, 1843 Elm St., Stratford, Conn. 1940
WOOD, HORACE W., JR., Professor of Civil Engineering University of Missouri, Columbia, Mo. 1931
WOOD, J. ALBERT, JR., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1938
WOOD, JOE N., Assistant Professor of Machine Design, Kansas State College, Manhattan, Kansas 1938
WOOD, KARL D., Professor of Aeronautical Engineering, Purdue University, Lafayette, Ind. 1941
WOODBURN, JAMES G., Professor of Hydraulic Engineering, University of Wisconsin, Madison, Wis. 1936
WOODBURY, CARL V., Professor and Head, Dept. of Physics, Norwich University, Northfield, Vt. 1940
WOODROW, JAY W., Professor and Head, Dept. of Physics, Iowa State College, Ames, Iowa 1934
WOODS, BALDWIN M., Professor of Mechanical Engineering, Director of University Extension, University of California, Berkeley, Calif. (*Member of Council, 1939–42; Second Vice President, 1942–43.*) .. 1930
WOODWARD, SHERMAN M., Chief, Water Control Planning Engineer, T.V.A., Knoxville, Tenn. (*Member of Council, 1913–6; 1926–29.*) 1910

WOOLEY, JOHN C., Professor of Agricultural Engineering, University of Missouri, Columbia, Mo. 1928
WOOLRICH, WILLIS R., Dean of Engineering, Professor of Mechanical Engineering, Director, Bureau of Engineering Research, University of Texas, Austin, Texas 1935
WORK, LINCOLN T., Director of Research and Development, Metal & Thermit Corp., P.O. Box 255, Rahway, N. J. 1923
WORK, WILLIAM R., Professor and Head, Department of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 1921
WORLEY, JOHN S., Professor of Transportation Engineering, University of Michigan, Ann Arbor, Mich. 1939
WORSENCROFT, ROBERT R., Instructor in Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. 1939
WORTHINGTON, CHARLES G., Secretary, Industrial Research Institute, 60 East 42nd St., New York City 1942
WRAY, JOE W., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. 1942
WRAY, ROBERT C., Associate Professor of Civil Engineering, University of Arkansas, Fayetteville, Ark. 1934
WRIGHT, CHILTON A., Professor of Hydraulic and Sanitary Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1938
WRIGHT, DONALD H., Instructor in Electrical Design, Pratt Institute, Brooklyn, N. Y. 1929
WRIGHT, HAROLD M., Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1937
WRIGHT, ROY V., Lecturer on Citizenship, Newark College of Engineering, Newark, N. J. 1936
WUNDERLEE, JAMES L., Instructor in General Engineering, Purdue University, Lafayette, Ind. 1922
YANOSIK, GEORGE A., Associate Professor of Mathematics, New York University, New York City 1938
YEATON, PHILIP O., Professor and Head, Dept. of Industrial Engineering, University of Florida, Gainesville, Fla. 1936
YELLOTT, JOHN I., Professor of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. 1936
YOUNG, ALMON P., Associate Professor of Mechanical Engineering, Michigan College of M. & T., Houghton, Mich. 1935
YOUNG, C. HIGBIE, Professor in Charge of Dept. of Machine Design, Cooper Union, New York City 1933
YOUNG, CLINTON M., Professor of Mining Engineering, University of Kansas, Lawrence, Kans. 1907
YOUNG, C. R., Dean, Faculty of Applied Science and Engineering, University of Toronto, Toronto, Ont. 1914
YOUNG, DANA, Professor and Head, Dept. of Civil Engineering, University Texas, Austin, Texas 1936
YOUNG, EDWARD, Assistant Professor of Geodesy and Surveying, University of Michigan, Ann Arbor, Mich. 1941
YOUNG, EVERETT G., Research Professor of Railway Mechanical Engineering, University of Illinois, Urbana, Ill. 1922
YOUNG, GILBERT A., Professor and Head, School of Mechanical Engineering, Purdue University, Lafayette, Ind. 1907
YOUNG, HERBERT R., Associate Professor of English, Case School of Applied Science, Cleveland, Ohio 1937
YOUNG, MILTON G., Acting Chairman, Dept. of Electrical Engineering, University of Delaware, Newark, Del. 1940

YOUNG, VINCENT W., Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. 1940
YOUNG, WILLIAM M., Dean, College of Applied Science, Ohio University, Athens, Ohio 1935
YOUNGER, JOHN, Professor of Industrial Engineering, The Ohio State University, Columbus, Ohio 1925
YOUNGER, JOHN E., Professor and Chairman, Dept. of Mechanical Engineering, University of Maryland, College Park, Md. 1938
ZAROBSKY, IVAN F., Professor of Mechanical Engineering, University of the City of Toledo, Toledo, Ohio 1928
ZBELL, SAMUEL P., Instructor in Mechanical Laboratory, Pratt Institute, Brooklyn, N. Y. 1941
ZELDIN, SAMUEL D., Assistant Professor of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. 1937
ZELLER, JOSEPH W., Head, Department of Mechanical Engineering, Northeastern University, Boston, Mass. 1926
ZELNER, OTTO S., Associate Professor of Surveying, University of Minnesota, Minneapolis, Minn. 1930
ZIMMER, ALBERT R., Professor of Electrical Engineering, University of Toronto, Toronto, Ont., Canada 1923
ZIMMERMAN, OSWALD T., Professor of Chemical Engineering, University of New Hampshire, Durham, N. H. 1935
ZIPPRODT, ROY R., Principal Civil Engineer, O. Q. M. G., War Dept., Washington, D. C. 1936
ZMESKAL, OTTO, Assistant Professor of Metallurgy, Illinois Institute of Technology, Chicago, Ill. 1941
ZOZZORA, FRANK, Instructor in Graphics, Lafayette College, Easton, Pa. 1942
ZUFFANTI, SAVERIO, Assistant Professor of Chemistry, Northeastern University, Boston, Mass. 1931

Total Individual Members 3306

ADDENDA.

DIMATTEO, JOHN E., Instructor in Engineering Drawing, Manhattan College, New York, N. Y. 1942
GRACE, CHARLES T., Assistant Professor of Mechanical Engineering, Iowa State College, Ames, Iowa 1942
SCHLEGEL, EDWARD J., Instructor in Mechanical Drawing, Bradley Polytechnic Institute, Peoria, Ill. 1942
THOMPSON, JESSE N., Assistant Professor of Civil Engineering, University of Texas, Austin, Texas 1942

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Davis, G. J., *Dean&P.C.E.*
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Shybekay, D. S., *Assoc.P.I.E.*
Taylor, W. H., *P.Dr.&Sur.*
Warnock, W G., *Asst.P.Math.*
Wilcox, D. B., *Assoc.P.I.E.*

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Berkeley

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Davis, R. E., *Dir.Eng.Mat.Lab.*
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Derleth, Chas., *P.&H.C.E.*
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McLaughlin, D. H., *Dean*
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Raber, B. F., *P.M.E.*
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Clayton, W. C., *Coord.Eng.Ed.*
Hall, S. R., *Sr.Des.Eng.*
Schroeder, Wm., *Res.Eng.*
Williams, G. K., *Struc.Eng.*

Claremont

Pomona College

Taylor, Ed., *P.Math.*

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University of California

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Walker, H. B., *P.Ag.E.*

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Glendale

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Bauer, G. C., *Ch.Draftsman*

Kentfield

Marin Junior College

Cherry, C. E., *Inst.Eng.&Math.*

Long Beach

Junior College

Black, L. T., *Inst.Eng.&Math.*

Los Angeles

Dougherty, J. W. *U.S.Eng.Dept.*
Ferry, A. L., 1965 N. Berendo
Holcomb, R. M.

Los Angeles City College

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Bardsley, C. E. S., 2910 Voelke Ave.
Birch, R. E., 1800 Farmers Bank Bldg.
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Hargis, A. B., *Sanitary*
Harkness, D. H., *Surveying; Trans.*
Harlow, H. G.
Harris, E. C., *Struc. Hydr.*
Hartman, Paul
Hathaway, A. S., *Surveying; Sanitary*
Haynes, H. G., *Engineering Drawing*
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Hendrick, T. K. A., *Struc.; Hydraulics*
Hennes, R. G., *Mech. & Mat.*
Hitchcock, W. W., *Surveying; Trans.*
Hoad, W. C., *Hydraulics; San. Eng.*
Hoadley, Anthony, *Structural*
Hoffman, O., *Mech. & Mat.*
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Holmes, F. E., *Surveying; Hydraulics*
Holt, A. H., *Surveying; Structural*
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Hooper, W. T.
Horan, F. W., *Structural; Sanitary*
Houk, H. H.
Housel, W. S., *Structural; Mech. & Mat.*
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Hume, Wm., *Drawing; Mech. & Mat.*
Huntington, W. C., *Mech. & Mat.*
Huntley, P. C., *Mech. & Mat.*
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Legget, R. F.

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Saxton, R. G., *Trans.; Hydraulics*
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Scofield, W. F., *Struc.; Hyd.*
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Sheiry, E. S., *Structural*
Sherlock, R. H., *Structural; Constr.*
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Sims, C. E.
Sims, J. R., *Drawing*
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Smith, Alva L.
Smith, F. M., *Surveying; Eng. Drawing*
Smith, G. I.
Smith, T. D.
Smith, W. S., *Surveying; Eng. Dr.*

Snader, D. L., *Struc.; Hydr.*
Snyder, M. K., *Structural; Sanitary*
Spears, S. M., *Structural; Surveying*
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Springer, G. P., *Trans.; Surveying*
Spry, F. J., *Surveying*
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Stevens, R. L., *Struc.; Transportation*
Stewart, L. O., *Survey.; Transportation*
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Swanson, H. A., *Struc., Survey.*
Sweetser, E. O., *Structural; Construction*
T'ang, C., *Struc., Hydraulics*
Taylor, A. D., *Mech. & Mat.*
Taylor, D. W., *Soil Mechanics*
Taylor, F. M., *Surveying*
Taylor, W. C., *Surveying; Sanitary*
Thatcher, R. Y., *Trans.; Economics*
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Thomas, F.
Thomas, H. A., *Hydraulics; Sanitary*
Thompson, H. L., *Sanitary*
Thompson, J. T., *Struc., Trans.*
Thompson, Sophus, *Struc.; Mech. & Mat.*
Timby, E. K., *Struc., Constr.*
Todd, M. W., *Surveying*
Tomlinson, G. E., *Construction*
Tracy, J. C.
Trezise, F. W., *Drawing*
Trively, I. A.
Trowbridge, D. S., *Survey.; Mech. & Mat.*
Troxwell, G. F., *Mech. & Mat.*
Tschebotarioff, G. P., *Soil Mech.*
Turner, A. S.
Uhler, E. H., *Structural; Mech. & Mat.*
Underwood, P. H., *Surveying; Math.*
Van Buren, M. H., *Struc.; Mech. & Mat.*
Van den Broek, J. A., *Struc.; Mech. & Mat.*
Van Driest, E. R., *Aeronautics*
Van Hagan, L. F., *Economics*
Van Ornum, J. L.
Vawter, J., *Structural*
Veit, R. C., *Structural*
Velz, C. J., *Sanitary*
Villemonte, J. R., *Hydr., Constr.*
Wagner, W. O., *Hydraulics*
Walker, S. B., *Patents*
Walther, C. H., *Structural*
Wandmacher, C., *Structural*
Watts, C. T., *Drawing*
Watwood, V. B.
Weaver, F. N., *Mech. & Mat.*
Weeden, H. A., *Mech. & Mat.*
Welch, F. W., *Surveying*
Wells, M. B., *Structural; Aeronautics*
Wendt, W. B., *Construction*
Wessman, H. E., *Structural; Constr.*
Whisler, B. A., *Sanitary*
White, J. R., *Mech. & Mat.*
White, K. R.
White, L. V., *Surveying*
White, K. P., *Architectural Eng.*
White, M. P.
Whitehead, L. W., *Surveying*
Wilbur, J. B., *Structural*
Wiley, C. C., *Transportation*
Williams, B. B., *Drawing*
Williams, J. P. J., *Hydraulics*
Williams, J. W.
Willig, W. L., *Surveying; Structural*
Wilsey, E. F.
Wilson, D. M., *Structural*
Wilson, F. C., *Sanitary*
Wilson, F. W., *Structural*
Wilson, W. E., *Hydraulics; Mechanics*
Wilson, W. M., *Structural; Mech. & Mat.*
Winfrey, R., *Valuation*
Winn, H. F., *Mech. & Mat.*
Winterkorn, H. F., *Soils*
Wiskocil, C. T., *Struc.; Hyd.*
Witmer, F. P., *Structural*
Wood, H. W., *Mech. & Mat.*
Woodburn, J. G., *Hydraulics*
Woodward, S. M., *Hydraulics*
Worley, J. S., *Transportation*
Wray, R. C., *Structural; Mech. & Mat.*
Wright, C. A., *Hydraulics; General*
Yasines, S. F., *Math.; Mech. & Mat.*
Young, E., *Surveying*
Zelner, O. S., *Surveying*
Zipprodt, R. R., *Structural; Construction*

ECONOMICS

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Bowman, D. O.
Cooley, H. B., *Civil, transportation*
Davey, H. W., *Social Science*
Ennis, W. D., *Ind. Eng.*
Garrett, S. S.
Goetz, B. E., *Industrial*
Grant, E. L., *Civil; Industrial*
Hastings, H. B., *Industrial*
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Lindemann, A. J., *Industrial*
McKenry, Nell
Miller, Nathan
Palmerton, L. R., *Eng.-Social Sci.*
Peterson, A. I., *Industrial; Mechanical*
Schweiger, A. J., *Government & Business*
Scrimshaw, Stewart
Simon, H. A., *Political Science*
Simonds, R. H., *Industrial*
Van Winkle, E. H.
Watson, W. S., *Psychology*
Wright, R. V., *Citizenship*

ELECTRICAL ENGINEERING

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Alliason, A. R., *Power; Communication*
Allured, R. B.
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Andres, P. G., *Communication*
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Bronwell, A. B., *Commun.*
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Jansky, C. M.

Jenkins, D. R.
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Kloeffler, R. G.
Knight, A. R., *Power; Illumination*
Knipmeyer, C. C., *Power; Mechanical*
Koerber, G. A.
Koopman, R. J. W.
Kraehenbuehl, J. O., *Power Comm.*
Kraybill, E. K., *General*
Kuhlmann, J. H., *Power*
Kurtz, E. B., *Power; Illumination*
Lamb, J. F., *Power*
Lange, E. O., *Power; Industrial*
Laning, W. A., *Communication*
Lansil, C. E., *Power*
Larsen, M. J., *Communication*
Larson, L. C., *Power*
Laurence, J., *Mathematics*
Leblanc, F.
Lear, J. E., *Illumination*
Lee, Claudius, *Physics*
Lehman, L. G., *Power*
Lickey, H. F., *Commun.; Illumination*
Lindvall, F. C., *Mechanical*
Liwschitz-Garik, M.
Locke, W. W., *Educational Administrator*
Lockwood, H. J., *Power; Communication*
Lott, A. O., *Mechanical*
Lovell, W. E.
Lovett, I. H., *Power*
Lueth, I. B., *Power*
Lutz, S. G., *Power; Communication*
Marchant, G. B., *Eng. Drawing; Math.*
Mallory, D. D., *Power*
Manning, M. L., *Power*
Markle, E. W., *Power*
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Maxfield, H. A.
Maxwell, F. R., *Power; Aeronautics*
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McClure, O. E., *Power; Physics*
McCrumm, J. D., *Power; Mathematics*
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Mills, G. H., *Power*
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Warner, R. G., *Power*
Warner, R. W., *Power*
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Watson, J. W.
Weber, Ernst, *Physics*
Weil, R. T., *Power*
Weinbach, M. P., *Power*
Welch, E. R., *Power*
Welke, R. A., *Economics*
Whipple, C. C., *Power; Illum.; Gen.*
White, W. T., *Eng. Dr.*
Widener, B. McK., *Illum.; Math.; Phys.*
Wildes, K. L., *Power*
Wilkinson, R. I., *Communication; Math.*
Williams, E. M., *Communication*
Williams, L. E., *Power*
Willis, B. S., *Power*
Willis, C. H., *Power*
Willson, F. G., *Power*
Wilson, J. W., *Power*
Wilson, N. E., *Power*
Wiltse, S. B., *Power*
Wing, A. H., *Comm., power, illuminating*
Winkler, E. W., *Power*
Wischmeyer, C. R., *Power*
Witham, R. L.
Wolf, H. E., *Physics*
Wood, F. R., *Mathematics*
Wood, J. A., *Communication*
Work, W. R., *Power*
Wright, D. H., *Power; Illumination*
Young, M. G., *Communication*
Zimmer, A. R., *Power*

ENGINEERING DRAWING

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Adams, W. E., *Aeronautics*
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Appleby, A. N., *Geology*
Arnold, J. N., *Electrical; General*
Atkinson, M. B., *Industrial*
Autenreith, G. C.
Balint, A. T., *Electrical*
Bauer, F. S., *Mechanical, machine design*
Berard, S. J., *Mechanical*
Bettencourt, W., *Shop*
Bragg, F. C., *Mechanical*
Brattin, C. L., *Mechanical; Mech. & Mat.*
Briggs, H. B., *Mechanical*
Brock, G. H.
Brooke, W. E., *Mathematics*
Brown, R. E., *Mathematics*
Brubaker, W. F., *Architectural*
Buck, C. P., *Civil*
Bukovsky, P. N.
Butler, J. H., *Mechanical; Mechanics*
Butler, R. S., *Civil, structural*
Castleman, J. R., *Civil*
Cecil, J. B., *Mech. & Mat.*
Chillman, E. F.
Cleary, S. F., *Mechanical, machine design*
Cleland, S. M., *Shop*
Clemens, G. J.
Cole, R. W.
Cooper, C. D.
Cooper, L. L.
Coppersmith, C. W., *Mech., mach. design*
Crossman, R. S., *Civil surveying*
Davis, D. E., *Mechanical; Mech. & Mat.*
Denis, Bro. A., *Mathematics*
Dent, J. B., *Civil; San. E.*
Devine, J. J., *Civil*
Dixon, D. P., *Architecture*
Dougherty, C. R. G., *Chemical Eng.*
Dowling, E. J., *English*
Dunkle, R. W.
Eckle, J. N., *Civil, structural*
Edgecombe, A. C., *Civil*
Eggers, H. C. T., *Mathematics*
Elrod, S. B., *Mechanical*
Fairbanks, O. W., *Mechanical*
Farnham, W. E., *Mechanical, mach. des.*
Fenwick, H. H., *Industrial; Mechanical*
Field, W. B., *Architecture*
Finch, F. R., *Mechanical, machine design*

Fitch, W. C., *Economics*
Fowler, R. W., *Mechanical, mach. design*
Freeman, M. L., *Architectural*
French, R. W., *Civil*
French, T. E.
Gatcombe, E. K.
Gerardi, Jasper, *Civil, surveying*
Gingrich, R. F.
Goodrich, A. L.
Gorman, W. M.
Grant, H. E.
Hachemeister, C. A., *Electrical*
Haentjes, C. H., *Mathematics*
Hales, V. D., *Civil, surveying*
Hall, S. G., *Mech. & Mat.*
Hayes, S. C. J., *Civil*
Heacock, F. A., *Civil; Sanitary*
Hein, J. M., *Architectural*
Henry, H. L., *Machine Design*
Hesse, H. C., *Mechanical, machine design*
Higbee, F. G.
Hill, F. M.
Hill, I. L., *Shop*
Hill, J. L., *Civil; Mechanical*
Hinkle, R. T.
Hoelscher, R. P., *Civil, structural*
Hoffman, P. C., *Mechanical*
Holland, U. C., *General; Shop*
Holman, L. W., *Architecture*
Hood, G. J.
Howe, L. B.
Hughes, F. R., *Civil, surveying*
Jewell, W. R., *Machine Design*
Johns, W. B., *Mechanics and Materials*
Johnson, L. O.
Johnson, M. F., *Civil; Mathematics*
Johnson, W. A.
Jones, L. D.
Jorgensen, Albert, *Civil; Mech. & Mat.*
Judson, W. J., *Machine Design*
Keaton, L. D., *Architecture*
Kent, B. C., *Machine Design*
Kiely, E. R.
Kleinschmidt, R. B., *Civil; Mathematics*
Kurtz, J. W., *Shop*
Ladner, A. C., *Math.; Mech. & Mat.*
Leighton, A. W.
Loving, R. O., *Mathematics*
Ludden, D. J., *Architectural*
Lurie, A. N., *Architecture; Mech. & Mat.*
Mann, C. V., *Civil; Psychology*
Mara, H. W., *Mathematics*
Markowitz, Jesse, *Aeronautics*
Maute, B. W., *Mathematics*
McCombs, G. C., *Civil, structural*
McConnell, R. K.
McCully, H. M.
McCully, H. M., Jr.
McFarland, J. D., *Electrical*
McGuire, J. G., *Architecture*
McKee, H. L., *Mechanical; Shop*
McNeary, Matthew, *Civil*
McNeill, W. H., *Civil*
Meadowcroft, N.
Meiklejohn, R.
Merrill, D. W., *Civil*
Meserve, G. H., *Civil, surveying*
Miller, F. C., *Mechanics and Materials*
Minkler, H. T.
Mitcham, J. T., *Mech. & Mat.*
Moore, E. R., *Shop*
Moose, P. E., *Civil, surveying*
Morris, H.
Mullins, B. F., *Civil, surveying*
Myers, H. D., *Civil, structural*
Narmore, P. B.
Nash, T. L., *General Physics*
Neal, H. P., *Mechanical*
Nettleton, E. B.
Nollau, L. E.
Normand, H. C., *Civil*
Northrup, R. T., *General*
Olson, O. A., *Mechanical*
O'Rourke, F. J., *Mathematics*
Orth, H. D.
Osborn, F. C., *General Eng.; Shop*
Osborne, D. S., *Mech. & Mat.*
Paffenbarger, R. S., *Chemical; Industrial*
Patten, L. M., *Architecture*
Paulsen, Fridtjof, *Math.; Mechanical*
Pearson, J. E.
Perrymen, C. C., *Industrial*
Phelps, G. M., *Civil, surveying*
Philby, A. J.
Pierce, S. H., *Electrical*
Pirchio, P. M., *Foreign Lang.; Shop*
Plock, Henry, *Civil*
Plummer, C. R., *Machine Design*
Polaner, J. L., *Mechanical*
Pollard, J. J., *General Eng.*
Porsch, J. H., *Civil; Mech. & Mat.*
Porter, F. M., *Architecture*
Potter, O. W., *Mineral Tech., metallurgy*
Pratt, G. M.
Quaid, L. J., *Hydraulics, math.*
Quinn, G. S., *Mech. & Mat.*
Radford, S. S., *Shop*
Rappolt, F. A.
Rising, Justus, *Mechanical; Shop*
Robertson, J. E., *Mathematics*
Rowe, C. E., *Min. Tech.*
Rule, J. T., *Mathematics*
Russ, J. M., *Mechanical; Shop*
Sawyer, R. A., *Civil*
Schumann, C. H., *Civil, structural*
Shiels, K. G., *Mechanical*
Slantz, F. W., *Civil; Mechanical*
Smith, G. B.
Smith, W. G., *Mechanical, machine design*
Smutz, F. A., *Mechanical, machine design*
Snook, R. C.
Spencer, H. C., *Architecture*
Springer, C. H., *Civil, structural*
Stevason, C. C., *Shop*
Stewart, E. H., *Architecture*
Stock, O. L., *Architecture*
Stone, O. M., *Architecture*
Stork, W. L., *Electrical*
Street, W. E., *Industrial; General*
Svensen, C. L., *Architecture*
Taylor, W. H.
Tea, P. L., *Mathematics*
Temple, E. H., *Mechanical, mach. design*
Thayer, H. R., *Civil; Sanitary*
Thomas, A. L., *Mechanical, mach. design*
Thomas, L. W., *General*
Toporeck, E. R., *Electrical*
Townsend, C. E.
Tozer, E. F., *Mechanical*
Turner, W. W., *Architecture*
Vidosic, J. P., *Mechanics*
Vierck, C. J.
Wagner, W. O., *Hydraulics*
Walker, L. D., *Civil, surveying*
Walsh, F. W., *Architecture*
Walsh, H. V.
Warner, F. M., *General*
Webb, E. C., *Shop*
Weber, H. S., *Mechanics and Materials*
Wellman, B. L., *Mech.; Mech. & Mat.*
Whenman, J. H., *Mechanical*
Willey, E. C., *Mechanical*
Williams, J. G.
Wilson, B. N., *Architectural*
Wilson, E. R., *Mechanical, mach. design*
Wood, A. B., *Mechanical, machine design*
Wood, J. N., *Electrical, illumination*
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ENGLISH

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Bowmer, W. S.
Brandt, C. G.
Brown, C. A.
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Burkland, C. E.
Callaghan, J. C., *Speech*
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Creek, H. L.
Crouch, W. G., *Foreign Lang.*
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Gertz, F. H.
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Harrison, T. P.
Hartley, L. C.
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Knoll, H. B.
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Morrison, E.
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Nyland, Waino
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Parr, Johnstone
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Pepper, L. R.
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Raw, R. M., *Economics*
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Scammon, W. F.
Sturmer, A. M., *For. Languages; Econ.*
Summey, George
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Groseclose, F. F., *Mechanical*
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Lucas, E. L., *Mechanical*
Lytle, C. W., *Economics*
Mabie, H. H., *Mechanical*
Mahaney, J. P., *Shop*
Millard, C. I., *Eng. Drawing; Mechanical*
Miller, A. M., *Economics*
Miller, J., *Economics*
Mock, C. O., *Drawing*
Morgan, J. C., *Cooperative*
Mundel, M. E., *General*
Norton, P. T., *Economics; Shop*
Pearce, F. W., *Mathematics*
Phelps, G. O., *Psychology*
Pigage, L. C., *Eng. Drawing*
Poole, H. M., *Shop*
Porter, D. B., *Mechanical, mfg. proc.*
Query, L. H., *Mechanical*
Rautenstrauch, Walter, *Economics*
Renner, W. E.
Rhodes, T. J., *Mechanical*
Riegel, J. W., *Economics*
Rix, C. N.
Robson, F. B.
Rogers, H. B., *General*
St. Clair, O. A., *Engineering Drawing*
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Renwick, D. J., *Eng. Drawing*
Repscha, A. H., *Heat Power; Power Pls.*
Reuling, W. E.
Rice, R. B., *Mechanics and Materials*
Richtmann, W. M., *Heat Power*
Riddle, K. W., *Machine Design; Shop*
Risteen, H. W., *Heat Power; Refrig*
Ritterbusch, H. F., *Mach. Design; Mech.*
Roberts, C. P., *Heat Power*
Roberts, E. G., *Mfg. Proc., Power Pl.*
Robertson, B. J., *Heat Power; Aeron.*
Robinson, O. L., *Fire Protection*
Roemmele, H. F., *Heat Power; Pr. Pls.*

Roesch, D., ***Automotive***
Rogers, F. S., ***Machine Design***
Rohrbach, G. E., ***Heat Power***
Roop, F. S., ***Heat Power; Power Plants***
Roudebush, R. E., ***Industrial***
Rubenkoenig, Harry, ***Mech. & Mat.***
Russell, D. M., ***Heat Power***
Ruten, W. H., ***Shop***
Ryan, D. G., ***Industrial***
Sager, E. H., ***Mfg. Proc.***
Sahag, L. M., ***Mach. Des.; Heat Power***
Salma, E. A., ***Mech. & Mat.***
Sanders, T. K.
Satterfield, H. E., ***Heat Power; Refrig.***
Scarth, Virgil
Schock, E. I., ***Mach. Des.; Architecture***
Schuck, R F., ***Machine Design***
Schulte, W. E.
Schutz, H.
Schwartz, F. L., ***Heat Pr.; Mech. & Mat***
Schweizer, P. E.
Scofield, J. H., ***Aeronautics***
Seegrist, W. H., ***Heat Power***
Seeley, L. E.
Setchell, J. E., ***Industrial***
Severns, W. H., ***Heat Power***
Seward, H. L., ***Heat Power***
Shallenberger, W. H., ***Heat Power***
Shenk, D. H., ***Heat Power; Refrigeration***
Sherwood, N. P., ***Heat, Power Pl.***
Sherwood, R. S.
Shigley, J. E., ***Drawing***
Shoop, C. F., ***Heat Power; Power Plants***
Short, B E., ***Heat Power***
Silha, H. W.
Simmang, C. M., ***Heat Power***
Simmons, C. M., ***Heat Power***
Simon, G. H., ***Heat Power; Power Plants***
Sims, E. M., ***Heat Power; Power Plants***
Skoglund, V. J., ***Heat Power***
Slaymaker, P. K., ***Machine Design***
Slaymaker, R. R., ***Mach. Des.; Mech. & Mat.***
Sloan, W. A., ***Heat Power; Power Plants***
Sloane, Alvin, ***Mach. Des.; Mech. & Mat.***
Sluss, A. H., ***Industrial; Shop***
Smith, E. B., ***Heat Power; Mech. & Mat.***
Smith, R. A., ***Mfg. Proc.; Heat Power***
Smith, R. K., ***Eng. Drawing***
Solberg, H. L., ***Heat Power; Power Pls.***
Sorensen, H. A., ***Heat Power***
Sorenson, A. E., ***Civil, hydraulics***
Spurlock, B. H., ***Heat Power***
Stanley, C. M., ***Textile***
Staples, A. J., ***Heat Power; Min. Tech.***
Starr, C., ***Shop***
Stearns, F. A., ***Heat Power***
Steele, A. L.
Stefani, Luis, ***Mach. Des.; Heat Power***
Stetkewicz, J. D., ***Metallurgy***
Stetson, G. A., ***Mech. & Mat.; Economics***
Stevens, H. E., ***Machine Design; Indus.***
Stevens, W. J., ***Mach. Des.; Mfg. Proc.***
Stewart, F. C., ***Heat Power; Refrig.***
Stiening, F. H., ***Mach. Des.; Refrig.***
Stimson, S. K., ***Mach. Des.; Mech. & Mat.***
Stinson, H. E., ***Acreonautics***
Stinson, K. W., ***Heat Power***
Stoever, H. J., ***Heat Power***
Stolworthy, E. H., ***Aeron.; Eng. Drawing***
Strate, J. T., ***Heat Power; Refrigeration***
Stuart, H. F.
Stuart, M. C., ***Heat Power; P. Plants***
Sullivan, F. J., ***Mach. Des.; Eng. Draw.***
Summers, R. E., ***Power Plants***
Svenson, C. L., ***Heat Power; Refrig.***
Sweigert, R. L., ***Heat Power***
Swett, G. W., ***Mach. Des.; Mech. & Mat.***
Swift, R. E., ***Metallurgy***
Swineford, C. R., ***Mach. Des.; Eng. Draw.***
Taft, T. H., ***Heat Power; Power Plants***
Tait, R. S., ***Machine Design***
Telle, L.
Thatcher, C. G., ***Heat Pr.; Mech. & Mat.***
Theiss, E. S., ***Industrial***
Thom, G. B., ***Heat Power; Refrigeration***
Thomas, F. H., ***Mfg. Processes; Indus.***
Thompson, J. G. H., ***Mach. Des.; Mfg. Proc.***
Thornburg, M. L., ***Heat Power; Refrig.***
Townsend, A. L., ***Mach. Des.; Mech. & Mat.***
Tracy, S. J., ***Mach. Des.; Heat Power***
Trigger, K. J., ***Mfg. Proc.; Heat Power***
Trotter, R. A., ***Machine Design***
Tripp, Wilson, ***Heat Power***
Truettner, W. I., ***Aeronautics***
Trumpler, P. R., ***H-P.; Power Plants***
Tuthill, A .F.
Tutt, C. L., ***Mach. Des., Mfg. Proc.***
Tuve, G. L., ***Heat Power***
Twogood, A. J
Tyrrell, C. C., ***Mechanics and Materials***
Ulcher, J. J., ***Heat Power***
Updegrove, H. T., ***Mfg. Proc.; Industrial***
Upp, C R., ***Heat Power; Power Plants***
Vail, R. P., ***Heat Power; Power Plants***
Vandergrift, C. G.
Van Dyke, J. R.
Venn, R. E., ***Drawing***
Vennum, R. R.
Vierck, R. K.
Vincent, E. T., ***Heat Power***
Vittucci, R. V., ***Heat Power; Refrig.***
Vopat, W. A., ***Heat Power; Power Plants***
Vose, F. H., ***Heat Power; Power Plants***
Walter, H E., ***Heat Power***
Walton, S. B., ***Mech. & Mat.***
Warren, A. J., ***Aeronautics***
Waterfall, H. W., ***Mach. Des.; Power Pl.***
Waters, E. O., ***Mach. Des.; Mathematics***
Watson, H. D., ***Heat Power***
Weber, A. R., ***Heat Power***
Webster, F. N., ***Power Plant***
Weibel, E. E.
Weiland, W. F.
Weishampel, J. A., ***Mech. & Mat.***
Weiss, H. A., ***Ind. Eng.; Machine Design***
Weiss, J. R., ***Power Plants***
Welch, H. E., ***Practical Science***
Wetzel, I. T., ***Electrical***
Wharton, J. R., ***Mach Des.; Refrigeration***
White, B. S., ***Machine Design***
Whittaker, A. E., ***Mech. & Mat.***
Wilbur, R. S., ***Heat Power***
Wilcox, C. C., ***Power Plant***
Williams, G. K., ***Min. Tech.***
Williams, R. D., ***Mineral Tech.***
Willis, P. A., ***General; Industrial***
Wilson, H. A., ***Machine Design***
Wilson, L. A., ***Heat Power; Refrigeration***
Wingren, R. M., ***Mach Des.; Mech. & Mat.***
Winston, S. E., ***Mach. Des.; Heat Power***
Wischmeyer, Carl, ***Heat Power; Refrig.***
Wohlenberg, W. J.
Wolowicz, C. H., ***Mech. & Met.***
Woods, B. M., ***Aero.; Min. Tech.***
Wright, H. M., ***Heat Power***
Yellott, J. I., ***Power Plants***
Young, A. P., ***Mech. & Mat.***
Young, C. H., ***Machine Design; Indus.***
Young, E. G., ***Mach. Des.***
Young, V. W., ***Aeronautics***
Younger, J. E., ***Aeronautics***
Zarobsky, I. F., ***Mach. Des.; Eng. Draw.***
Zbell, S. P., ***General; Draw.***
Zeller, J. W.

MECHANICS AND MATERIALS

Andrews, C. B., ***Civil, surveying***
Beal, R. W., ***Mechanical, heat power***

Bechtold, C. W.
Bernhard, R. K.
Berryman, L. G., *Metallurgy*
Bliss, Z. R., *Economics; Machine Design*
Boomsliter, G. P., *Mechanical; Civil*
Boyd, J. E.
Breneman, J. W., *Civil Eng.*
Brown, F. L.
Bullard, J. A., *Mathematics*
Cade, C. M., *Civil, surveying*
Carey, R. H., *Civil, structural*
Cassel, E. B., *Drawing*
Cather, C. H., *Mechanical; Mach. Design*
Chamberlin, S. J., *Civil; Eng. Drawing*
Chambers, S. D.
Clark, E. C.
Clark, L. W., *Struc.*
Colbert, J. P., *Civil, structural*
Collins, W. L., *Civil, structural*
Conley, W. J.
Conner, N. W., *Mechanical; Aeronautics*
Cook, R. M., *Civil*
Cornell, W. R., *Mechanical*
Cox, W. J.
Cutshall, C. S., *Chemical*
Dahlene, Oscar, *Mathematics*
Dawley, E. R., *Civil, structural*
De Baufre, W. L., *Mech.; Eng. Drawing*
Dietz, A. G. H., *Bldg. Eng.*
Dodge, R. A., *Hydraulics*
Doerr, L. O., *Mechanical, machine design*
Dohrenwend, C. O., *Civil; Mathematics*
Dolan, T. J., *Civil; Mechanical*
Doll, A. W., *Physics*
Dougherty, J. W.
Downing, D. G., *Engineering Drawing*
Draffin, J. O., *Civil; Sanitary*
Dudley, W. M., *Mechanical, Mach. design*
Duff, C. M., *Civil*
Eberhart, H. D., *Civil*
Edgar, R. F., *Civil; Drawing*
Edgecomb, R. E.
Ensign, N. E., *Mathematics*
Eriksen, E. L., *Civil; Aeronautics*
Ermenc, J. J.
Ernst, G. C., *Civil, structural*
Evans, T. H., *Civil, structural*
Everett, F. L., *Machine Design*
Fairman, Seibert, *Aeronautics*
Flanders, R. L., *Civil*
Folk, S. B., *Civil, hydraulics*
Freire, Vida A.
Frigon, R. A., *Mechanical*
Frocht, M. M., *Machine Des.; Math.*
Fuller, C. E.
Getchell, E. L., *Mechanical*
Gilkey, H. J., *Civil*
Girvin, H. F., *Mechanical; Industrial*
Goodier, J. N., *Mathematics*
Grone, E. A., *Drawing*
Haddox, L. C., *Physics*
Harris, C. O., *Structural*
Hartenberg, R. S., *Math; Aeronautics*
Hawkins, R. D.
Herrick, C. A., *Mechanical; Mathematics*
Herrick, T. J., *Mechanical*
Higdon, R. A., *Mathematics*
Higgins, P. R., *Aeronautics*
Holme, J. M.
Howe, J. W., *Hydraulics*
Howell, E. V., *Mathematics*
Hudson, R. C., *Drawing*
James, R. V., *General*
Jensen, A., *Arch. Eng.*
Jones, P. G.
Jones, R. W.
Kingman, E. D., *English*
Koenitzer, L. H., *Civil, hydraulics*
Kommers, J. B., *Mechanical, mach. des.*
Kurzweil, A. C., *Mechanical*
Lansford, W. M., *Civil, hydraulics*
Laurson, P. G., *Civil, structural*
Lee, G. H.
Lightburn, F. E., *Highway*
MacCullough, G. H., *Mechanical*
Mangold, J. F.
Marin, Joseph, *Civil; Mechanical*
Maurer, E. R.
Mayrose, H. E., *Mechanical*
McLean, W. G., *Mathematics*
Miller, F. E., *Mathematics*
Moore, H. F., *Mechanical; Metallurgy*
Murphy, Glenn, *Civil, structural*
Myklestad, N. O., *Mechanical*
Newman, M. K., *Physics*
Ocvirk, F. W.
Olsen, G. A., *Mech. & Mat.*
Ormondroyd, J.
Ott, P. W., *Civil, hydraulics*
Paul, C. E., *General Eng.*
Paustian, John
Peck, J. S., *Structural; Psychology*
Perkins, H. C., *Mechanical; shop*
Peterson, A. C., *Sanitary*
Pletta, D. H.
Poorman, A. P., *Civil, structural*
Powell, R. W., *Civil, hydraulics*
Preston, H. K.
Priester, G. C., *Mathematics*
Reissner, H. J., *Aeronautics*
Richmond, R. F., *Drawing*
Roark, R. J., *Aeronautics; C. E.*
Robert, J. H., *Civil, hydraulics*
Sanders, W. B., *Chemical*
Sayre, M. F., *Mechanical*
Scholer, C. H., *Civil, structural*
Schoonover, R. H., *Structural; Math.*
Schrader, H. J., *Mechanical*
Seely, F. B., *Mech.; Civil, hydraulics*
Singer, F. L., *Mech.; Eng. Drawing*
Smith, F. H., *Drawing*
Smith, G. W., *Civil*
Smith, J. O., *Mathematics*
Sollenberger, N. J., *Civil, structural*
Staley, H. R., *Civil*
Stephen, E. R., *Mechanical, mach. des.*
Stiles, W. B., *Electrical, illumination*
Stitz, E. O., *Chemical*
Switzer, F. G., *Mechanical; Mathematics*
Taylor, D. C., *Civil; Foreign Lang.*
Thomas, Evan, *Mathematics*
Timoshenko, S. P.
Trathen, R. H.
Tucker, LeRoy, *Civil; Geology*
Vennard, J. K., *Hydraulics*
Wade, F. H., *Hydraulics*
Ward, Sam., *Civil*
Wendt, K. F., *Civil*
Whetstone, G. A., *Mathematics*
Williams, G. K., *Electrical*
Wiseman, E. R., *Civil*
Withey, M. O., *Civil*
Wood, E. H.
Young, Dana

MINERAL TECHNOLOGY

Barker, G. J., *Chem. Eng.*
Baxter, C. H., *Mining*
Berry, G. M., *Metallurgy; Shop*
Bischof, G. J., *Mechanical*
Black, R. M., *Mining*
Bolotsky, Max, *Metallurgy*
Bucky, P. B., *Mining*
Budge, W. E., *Mining*
Butts, Allison, *Metallurgy*
Carpenter, A. H., *Metallurgy; Geology*
Cloud, W. F., *Pet. & Nat. Gas*
Cockrell, W. L., *Metallurgy; Chemical*
Coffinberry, A. S., *Metallurgy*
Cothern, L. I.

Cover, G. M., *Metallurgy*
Craft, B. C., *Pet. & Nat. Gas; Geology*
Cunningham, J. B., *Mining; Metallurgy*
Daniels, Joseph, *Mining; Metallurgy*
Doan, G. E., *Metallurgy*
Dodge, J. F., *Petroleum and Natural Gas*
Dowdell, R. L., *Metallurgy*
Drier, R. W., *Metallurgy; Physics*
Eckfeldt, Howard, *Mining; Min. Dressing*
Eddy, C. T., *Metallurgy*
Fitterer, G. R., *Metallurgy*
Gaudin, A. M., *Mineral Dressing*
Goodale, S. L., *Metallurgy*
Grider, R. L., *Mining; Eng. Drawing*
Grosvenor, A. W., *Metallurgy*
Gudebski, H. C., *Metallurgy*
Haga, L. J., *Chemical*
Hess, W. F., *Met.; Physics; Elec. E.*
Horn, C. R., *Pet. & Nat. Gas*
Hunter, M. A., *Metallurgy*
Kehl, G. L., *Metallurgy*
Kinney, E. D., *Metallurgy; Geology*
Lazan, B. J., *Metallurgy*
Lewis, J. F., *Mining; Pet. & Nat. Gas*
Lewis, R. S., *Mining; Mineral Dressing*
Locke, C. E., *Mining; Mineral Dressing*
Mackay, Scott, *Metallurgy*
Mahin, G. E., *Metallurgy*
Manderfield, N. H., *Metallurgy; Chemical*
Mathewson, C. H., *Metallurgy*
Mathewson, E. P., *Metallurgy*
Mauffette, P., *Mining, Geology*
McCaffery, R. S., *Mining; Metallurgy*
Miller, E. C., *Metallurgy; Min. Dress.*
Milligan, W. E., *Metallurgy; Chemistry*
Nelson, W. L., *Pet. & Nat. Gas*
Nicholson, H. P., *Mining; Mineral Dressing*
Noble, G. W., *Economics*
Nold, H. E., *Mining*
Ockerblad, A. M., *Surveying*
Oesterle, J. F., *Metallurgy; Physics*
Parker, J. M., *Geology*
Parker, W. H., *Mining; Pet. & Nat. Gas*
Phillips, Arthur, *Metallurgy*
Plank, W. B., *Mining; Metallurgy*
Power, H. H., *Pet. & Nat. Gas; Chemical*
Queneau, B. R., *Metallurgy*
Quier, K. E., *Heat Power, Power Plants*
Read, T. T., *Mining*
Ross, F. W., *Mathematics*
Schramm, E. F.
Schulte, W. C., *Metallurgy; Mechanical*
Schuhmann, R.
Sellers, G. A., *Metallurgy; Industrial*
Serviss, F. LeV., *Geology*
Sherman, G. W., *Metallurgy*
Sherrill, R. E., *Gas & Geology*
Spindler, W. A., *Metal Proc.*
Stephenson, E. A., *Pet. and Nat. Gas*
Stewart, J. W., *Mining*
Straley, H. W., *General Eng.*
Stuckey, J. L., *Geology*
Swift, R. E., *Metallurgy*
Taggart, A. F., *Min. Dressing; Chemical*
Talmadge, S. B., *Mining; Geology*
Underhill, James, *Mining; General*
Upthegrove, C., *Metallurgy*
Uren, L. C., *Petroleum*
Vance, Harold, *Pet. and Natural Gas*
Van Note, W. G., *Ceramics*
Sherman, G. W., *Metallurgy*
Wagner, H. A., *Mining; Metallurgy*
Weysser, J. L. G., *Metallurgy*
White, H. V., *Metallurgy*
Williams, D. C., *Mining; Geology*
Witmer, L. F., *Metallurgy*
Young, C. M., *Mining; Metallurgy*
Zmeskal, O., *Metallurgy*

PHYSICS

Abbitt, W. H.
Abbott, R. B., *Electrical*
Backer, L. B., *Civil, construction*
Ball, Albert
Banks, C. W., *Civil; Mech. & Mat.*
Bartlett, G. W.
Bennett, C. E., *Mathematics*
Berggren, W. P., *Mech. & Mat.*
Bessey, W. H., *General Eng.*
Bidwell, C. C.
Birge, R. T.
Bishop, F. L.
Bliss, H. H., *Gen. Eng.*
Brewington, G. P.
Brown, F. L., *Mathematics*
Clouse, J. H., *Mechanical; Mech. & Mat*
Collins, G. B., *Electrical*
Colvert, W. W., *Mathematics*
Coolidge, J. A., *Mathematics*
Cooper, F. L.
Copeland, P. L.
Countryman, M. A., *Electrical*
Driscoll, W. G., *Mathematics*
Duncan, David C., *Mathematics*
Durbin, F. M.
Elliot, D. S., *General*
Entwisle, F. N., *Psychology*
Fraim, P. B., *Geology*
Fry, H. M., *Electrical; Mathematics*
Gager, F. M., *Electrical; General*
George, V. C., *Mathematics; Mechanical*
Griset, H. E.
Guthrie, A. N.
Gwinn, I. J., *Engineering Drawing*
Hall, V. B., *Eng. Drawing; Mechanical*
Halsey, Hugh
Hammond, T. M., *Mathematics*
Hawkes, J. B.
Hazeltine, L. A., *Mechanical*
Henderson, R. B.
Herreman, H. M., *Electrical*
Hertel, K. L.
Hett, J. H., *Mathematics*
Hilberry, Norman
Hottle, W. M., *Electrical*
Hyslop, W. H.
Ingersoll, L. R., *Heat Power*
Jones, L. W., *Electrical, communication*
Jones, M. W.
Kenrick, G. W., *Electrical, commun.*
Kovarik, A. F.
Laestadius, J. E.
Lambe, E. P., *Electrical, power*
Lancaster, F. W., *Chemistry; Math.*
Lark-Horovitz, K.
Mallory, F.
Meares, J. S.
Merritt, H. W., *Mechanics and Materials*
Muckenhoupt, C. F., *Electrical; Math.*
Myers, F. E.
Partlo, F. L., *Mathematics*
Patterson, R. A.
Pheley, D. B., *Civil, surveying*
Pietenpol, W. B.
Piper, F. F., *Electrical*
Pomeroy, G. A.
Porter, R. A.
Potter, J. G., *General Enginering*
Pugh, E. M., *Electrical*
Richardson, D. E., *Communications*
Robert, R. A., *Mathematics*
Sagen, G. O., *Mathematics*
St. Peter, W. N.
Sartain, C. C., *Electrical*
Schmidt, H. P., *Mech.; Mech. & Mat.*
Silvey, O. W.
Sizelove, O. J.
Slack, E. P., *Electrical*
Slack, F. G.

Smith, E. G., *Mechanical*
Smith, T. T.
Spinney, L. B., *Electrical*
Stearns, J. C.
Stempel, W. M., *Optics*
Stewart, G. W.
Swaim, V. F.
Thompson, J. S.
Toole, C. E., *Electrical; Mechanical*
Webster, J. C., *Mechanical; General*
Wheeler, N. E.
Whitaker, M. D.
Woodbury, C. V., *Aeronautics*
Woodrow, J. W., *Mathematics*
Woods, F. P.

PSYCHOLOGY

Boder, D. P.
Carter, C. C.
Hicks, W. N., *Ethics & Religion*
Johnson, A. P., *Personnel & Indus. Rel.*
Kopas, J. S., *Electrical, communication*
Magoun, F. A.
O'Connor, Johnson
Palmerton, L. R.
Schaefer, V. G.
Swartz, B. K., *Economics*
Watson, W. S.

SANITARY ENGINEERING

Babbitt, H. E., *Chemistry; Civil*
Boyce, Earnest, *Civil*
Brown, E. S., *Civil, surveying*
Camp, T. R., *Chemical; Civil*
Cheek, F. J., *Hydraulics*
Dunstan, G. H., *Hydraulics*
Evinger, M. I., *Civil, hydraulics*
Fair, G. M.
Gotaas, H. B., *Civil, hydraulics*
Haney, P. D., *Chemical*
Hinman, J. J., *Chemical; Chemistry*
Howland, W. E., *Civil, hydraulics*
Hyde, C. G., *Civil*
Jones, D. K., *Hydraulics*
Kilcawley, E. J., *Soil Mech.*
Miles, H. J., *Civil, hydraulics*
O'Donnel, Raymond, *Civil, hydraulics*
Payrow, H. G., *Civil, hydraulics*
Perry, Lynn, *Civil, surveying*
Robbins, J. M., *Civil, surveying*
Rohlich, G. A., *Hydraulics*
Stanley, W. E., *Civil, hydraulics*
Stapley, E. R., *Civil, hydraulics*
Steel, E. W., *Civil*
Suttle, R. H., *Civil, hydraulics*
Vander Velde, T. L., *Civil, surveying*
Walker, C. L., *Civil*
Waterman, E. L., *Civil*
Wolman, Abel

SHOP AND MECHANIC ARTS

Beatty, H. R., *General; Industrial*
Benedict, Otis, *Mechanical, mach. design*
Bjerg, H. O., *Crafts*
Bourdelais, G. A., *Engineering Drawing*
Bradley, F. R.
Burley, J. W.
Carlson, W. W., *Mechanical*
Cobb, C. N., *Industrial Eng.*
Delenk, W. N., *Mfg. Proc.*
Geer, R. L., *Mech. & Mat.*
Hunt, De Witt
Jones, C. B., *Forging, heat treating*
Jones, E. C., *Mechanical*
Lindley, R. W.
Nesbitt, R. E., *Mechanical*
O'Rourke, F. J.
Rice, W. H., *Welding*
Rix, C. N., *Mechanical*
Rowland, M. R., *Mechanical; Eng. Draw.*
Small, E. H., *Electrical, power*
Soderstrom, E. D.
Starr, C. J., *Mechanical, mfg. processes*
Tonkin, J. C., *Mechanical, mfg. processes*
Trueblood, R. B., *Mechanical*
Welch, H. E., *Drawing*
Wendt, R. E., *General*
Wheeler, F. B.
Wittig, F. E., *Heat Power*
Wunderlee, J. L., *General*

Cover, G. M., *Metallurgy*
Craft, B. C., *Pet. & Nat. Gas; Geology*
Cunningham, J. B., *Mining; Metallurgy*
Daniels, Joseph, *Mining; Metallurgy*
Doan, G. E., *Metallurgy*
Dodge, J. F., *Petroleum and Natural Gas*
Dowdell, R. L., *Metallurgy*
Drier, R. W., *Metallurgy; Physics*
Eckfeldt, Howard, *Mining; Min. Dressing*
Eddy, C. T., *Metallurgy*
Fitterer, G. R., *Metallurgy*
Gaudin, A. M., *Mineral Dressing*
Goodale, S. L., *Metallurgy*
Grider, R. L., *Mining; Eng. Drawing*
Grosvenor, A. W., *Metallurgy*
Gudebski, H. C., *Metallurgy*
Haga, L. J., *Chemical*
Hess, W. F., *Met.; Physics; Elec. E.*
Horn, C. R., *Pet. & Nat. Gas*
Hunter, M. A., *Metallurgy*
Kehl, G. L., *Metallurgy*
Kinney, E. D., *Metallurgy; Geology*
Lazan, B. J., *Metallurgy*
Lewis, J. F., *Mining; Pet. & Nat. Gas*
Lewis, R. S., *Mining; Mineral Dressing*
Locke, C. E., *Mining; Mineral Dressing*
Mackay, Scott, *Metallurgy*
Mahin, G. E., *Metallurgy*
Manderfield, N. H., *Metallurgy; Chemical*
Mathewson, C. H., *Metallurgy*
Mathewson, E. P., *Metallurgy*
Mauffette, P., *Mining, Geology*
McCaffery, R. S., *Mining; Metallurgy*
Miller, E. C., *Metallurgy; Min. Dress.*
Milligan, W. E., *Metallurgy; Chemistry*
Nelson, W. L., *Pet. & Nat. Gas*
Nicholson, H. P., *Mining; Mineral Dressing*
Noble, G. W., *Economics*
Nold, H. E., *Mining*
Ockerblad, A. M., *Surveying*
Oesterle, J. F., *Metallurgy; Physics*
Parker, J. M., *Geology*
Parker, W. H., *Mining; Pet. & Nat. Gas*
Phillips, Arthur, *Metallurgy*
Plank, W. B., *Mining; Metallurgy*
Power, H. H., *Pet. & Nat. Gas; Chemical*
Queneau, B. R., *Metallurgy*
Quier, K. E., *Heat Power, Power Plants*
Read, T. T., *Mining*
Ross, F. W., *Mathematics*
Schramm, E. F.
Schulte, W. C., *Metallurgy; Mechanical*
Schuhmann, R.
Sellers, G. A., *Metallurgy; Industrial*
Serviss, F. LeV., *Geology*
Sherman, G. W., *Metallurgy*
Sherrill, R. E., *Gas & Geology*
Spindler, W. A., *Metal Proc.*
Stephenson, E. A., *Pet. and Nat. Gas*
Stewart, J. W., *Mining*
Straley, H. W., *General Eng.*
Stuckey, J. L., *Geology*
Swift, R. E., *Metallurgy*
Taggart, A. F., *Min. Dressing; Chemical*
Talmadge, S. B., *Mining; Geology*
Underhill, James, *Mining; General*
Upthegrove, C., *Metallurgy*
Uren, L. C., *Petroleum*
Vance, Harold, *Pet. and Natural Gas*
Van Note, W. G., *Ceramics*
Sherman, G. W., *Metallurgy*
Wagner, H. A., *Mining; Metallurgy*
Weysser, J. L. G., *Metallurgy*
White, H. V., *Metallurgy*
Williams, D. C., *Mining; Geology*
Witmer, L. F., *Metallurgy*
Young, C. M., *Mining; Metallurgy*
Zmeskal, O., *Metallurgy*

PHYSICS

Abbitt, W. H.
Abbott, R. B., *Electrical*
Backer, L. B., *Civil, construction*
Ball, Albert
Banks, C. W., *Civil; Mech. & Mat.*
Bartlett, G. W.
Bennett, C. E., *Mathematics*
Berggren, W. P., *Mech. & Mat.*
Bessey, W. H., *General Eng.*
Bidwell, C. C.
Birge, R. T.
Bishop, F. L.
Bliss, H. H., *Gen. Eng.*
Brewington, G. P.
Brown, F. L., *Mathematics*
Clouse, J. H., *Mechanical; Mech. & Mat*
Collins, G. B., *Electrical*
Colvert, W. W., *Mathematics*
Coolidge, J. A., *Mathematics*
Cooper, F. L.
Copeland, P. L.
Countryman, M. A., *Electrical*
Driscoll, W. G., *Mathematics*
Duncan, David C., *Mathematics*
Durbin, F. M.
Elliot, D. S., *General*
Entwisle, F. N., *Psychology*
Fraim, P. B., *Geology*
Fry, H. M., *Electrical; Mathematics*
Gager, F. M., *Electrical; General*
George, V. C., *Mathematics; Mechanical*
Griset, H. E.
Guthrie, A. N.
Gwinn, I. J., *Engineering Drawing*
Hall, V. B., *Eng. Drawing; Mechanical*
Halsey, Hugh
Hammond, T. M., *Mathematics*
Hawkes, J. B.
Hazeltine, L. A., *Mechanical*
Henderson, R. B.
Herreman, H. M., *Electrical*
Hertel, K. L.
Hett, J. H., *Mathematics*
Hilberry, Norman
Hottle, W. M., *Electrical*
Hyslop, W. H.
Ingersoll, L. R., *Heat Power*
Jones, L. W., *Electrical, communication*
Jones, M. W.
Kenrick, G. W., *Electrical, commun.*
Kovarik, A. F.
Laestadius, J. E.
Lambe, E. P., *Electrical, power*
Lancaster, F. W., *Chemistry; Math.*
Lark-Horovitz, K.
Mallory, F.
Meares, J. S.
Merritt, H. W., *Mechanics and Materials*
Muckenhoupt, C. F., *Electrical; Math.*
Myers, F. E.
Partlo, F. L., *Mathematics*
Patterson, R. A.
Pheley, D. R., *Civil, surveying*
Pietenpol, W. B.
Piper, F. F., *Electrical*
Pomeroy, G. A.
Porter, R. A.
Potter, J. G., *General Enginering*
Pugh, E. M., *Electrical*
Richardson, D. E., *Communications*
Robert, R. A., *Mathematics*
Sagen, G. O., *Mathematics*
St. Peter, W. N.
Sartain, C. C., *Electrical*
Schmidt, H. P., *Mech.; Mech. & Mat.*
Silvey, O. W.
Sizelove, O. J.
Slack, E. P., *Electrical*
Slack, F. G.

Smith, E. G., *Mechanical*
Smith, T. T.
Spinney, L. B., *Electrical*
Stearns, J. C.
Stempel, W. M., *Optics*
Stewart, G. W.
Swaim, V. F.
Thompson, J. S.
Toole, C. E., *Electrical; Mechanical*
Webster, J. C., *Mechanical; General*
Wheeler, N. E.
Whitaker, M. D.
Woodbury, C. V., *Aeronautics*
Woodrow, J. W., *Mathematics*
Woods, F. P.

PSYCHOLOGY

Boder, D. P.
Carter, C. C.
Hicks, W. N., *Ethics & Religion*
Johnson, A. P., *Personnel & Indus. Rel.*
Kopas, J. S., *Electrical, communication*
Magoun, F. A.
O'Connor, Johnson
Palmerton, L. R.
Schaefer, V. G.
Swartz, B. K., *Economics*
Watson, W. S.

SANITARY ENGINEERING

Babbitt, H. E., *Chemistry; Civil*
Boyce, Earnest, *Civil*
Brown, E. S., *Civil, surveying*
Camp, T. R., *Chemical; Civil*
Cheek, F. J., *Hydraulics*
Dunstan, G. H., *Hydraulics*
Evinger, M. I., *Civil, hydraulics*
Fair, G. M.
Gotaas, H. B., *Civil, hydraulics*
Haney, P. D., *Chemical*
Hinman, J. J., *Chemical; Chemistry*
Howland, W. E., *Civil, hydraulics*
Hyde, C. G., *Civil*
Jones, D. K., *Hydraulics*
Kilcawley, E. J., *Soil Mech.*
Miles, H. J., *Civil, hydraulics*
O'Donnel, Raymond, *Civil, hydraulics*
Payrow, H. G., *Civil, hydraulics*
Perry, Lynn, *Civil, surveying*
Robbins, J. M., *Civil, surveying*
Rohlich, G. A., *Hydraulics*
Stanley, W. E., *Civil, hydraulics*
Stapley, E. R., *Civil, hydraulics*
Steel, E. W., *Civil*
Suttle, R. H., *Civil, hydraulics*
Vander Velde, T. L., *Civil, surveying*
Walker, C. L., *Civil*
Waterman, E. L., *Civil*
Wolman, Abel

SHOP AND MECHANIC ARTS

Beatty, H. R., *General; Industrial*
Benedict, Otis, *Mechanical, mach. design*
Bjerg, H. O., *Crafts*
Bourdelais, G. A., *Engineering Drawing*
Bradley, F. R.
Burley, J. W.
Carlson, W. W., *Mechanical*
Cobb, C. N., *Industrial Eng.*
Delenk, W. N., *Mfg. Proc.*
Geer, R. L., *Mech. & Mat.*
Hunt, De Witt
Jones, C. B., *Forging, heat treating*
Jones, E. C., *Mechanical*
Lindley, R. W.
Nesbitt, R. E., *Mechanical*
O'Rourke, F. J.
Rice, W. H., *Welding*
Rix, C. N., *Mechanical*
Rowland, M. R., *Mechanical; Eng. Draw.*
Small, E. H., *Electrical, power*
Soderstrom, E. D.
Starr, C. J., *Mechanical, mfg. processes*
Tonkin, J. C., *Mechanical, mfg. processes*
Trueblood, R. B., *Mechanical*
Welch, H. E., *Drawing*
Wendt, R. E., *General*
Wheeler, F. B.
Wittig, F. E., *Heat Power*
Wunderlee, J. L., *General*

TOTAL MEMBERS, PAST AND PRESENT.

INDIVIDUAL

Aug.	20, 1894	156	
Sept.	2, 1895	184	
Aug.	20, 1896	200	(about)
Aug.	16, 1897	203	
Aug.	18, 1898	226	
Aug.	17, 1899	238	
July	2, 1900	249	
June	29, 1901	261	
June	27, 1902	253	
July	1, 1903	271	
Sept.	1, 1904	325	
June	28, 1905	379	
July	2, 1906	400	
July	1, 1907	415	
June	27, 1908	675	
June	24, 1909	759	
June	23, 1910	848	
June	27, 1911	1,071	
June,	1912	1,102	
June,	1913	1,158	
March,	1914	1,339	
July	1, 1915	1,452	
March,	1916	1,504	
March,	1917	1,505	
March,	1918	1,506	
April,	1920	1,511	
April,	1922	1,589	
March,	1923	1,694	
March,	1926	1,988	
June,	1927	1,995	
May,	1928	2,025	
Nov.,	1929	2,169	
Nov.	1, 1930	2,192	
Nov.	30, 1931	2,274	
Nov.	8, 1932	2,227	
Jan.	27, 1934	2,271	
Jan.	1, 1935	2,453	
Feb.,	1, 1937	2,490	
Feb.	10, 1938	2,901	
Feb.	1939	2,929	
Feb.	1940	3,086	
Feb.	1941	3,220	
Feb.	1942	3,269	
Feb.	1943	3,306	

Individual Members	3,306
Institutional Members	154
Total Membership	3,460

MEETINGS OF THE S. P. E. E.

1893, July 30–Aug. 5......	Chicago, Ill.*	I. O. Baker, Univ. of Ill. (Chairman, Section E.)
1894, Aug. 20–21...........	Brooklyn Polytechnic Institute, Brooklyn, N. Y.	DeVolson Wood, Stevens Inst. of Technology.
1895. Sept. 2–4............	Springfield, Mass.	G. F. Swain, Massachusetts Inst. of Technology.
1896, Aug. 20–22...........	Buffalo, N. Y.	Mansfield Merriman, Lehigh Univ.
1897, Aug. 16–18...........	University of Toronto, Toronto, Ontario.	H. T. Eddy, Univ. of Minn.
1898, Aug. 18–20...........	Boston, Mass.	J. B. Johnson, Wash. Univ., Missouri.
1899, Aug. 17–19...........	The Ohio State University, Columbus, O.	T. C. Mendenhall, Worcester Polytechnic Inst.
1900, July 2–3.............	Columbia University, New York City.	I. O. Baker, Univ. of Ill.
1901, June 29–July 2......	Buffalo, N. Y.	F. O. Marvin, Univ. of Kans.
1902, June 27–28...........	Pittsburgh, Pa.	Robert Fletcher, Dartmouth College.
1903, July 1–3.............	Niagara Falls, N. Y.	C. M. Woodward, Wash Univ., St. Louis.
1904, Sept. 1–3............	St. Louis, Mo.	C. F. Allen, Mass. Inst. of Technology.
1905, June 28–29...........	Atlantic City, N. J.	F. W. McNair, Mich. Coll. of Mines.
1906, July 2–3.............	Cornell University, Ithaca, N. Y.	C. L. Crandall, Cornell Univ.
1907, July 1–3.............	Case School of Applied Science, Cleveland, O.	D. C. Jackson, M. I. T.
1908, June 24–27...........	Detroit, Mich.	Chas. S. Howe, Case School of Applied Science.
1909, June 24–26...........	Columbia University, New York City.	F. E. Turneaure, Univ. of Wis.
1910, June 23–25...........	University of Wisconsin, Madison, Wis.	H. S. Munroe, Columbia Univ.
1911, June 27–29...........	Carnegie Institute of Technology and the University of Pittsburgh, Pittsburgh, Pa.	A. N. Talbot, Univ. of Ill.
1912, June 26–29...........	M. I. T., Harvard and Wentworth, Boston, Mass.	W. G. Raymond, Univ. of Iowa.
1913, June 24–26...........	University of Minnesota, Minneapolis, Minn.	W. T. Magruder, Ohio State Univ.
1914, June 23–26...........	Princeton University, Princeton, N. J.	G. C. Anthony, Tufts College, Mass.
1915, June 22–25...........	Iowa State College, Ames, Ia.	Anson Marston, Iowa State College.
1916, June 19–22...........	University of Virginia, University, Va.	H. S. Jacoby, Cornell Univ.
1917, July 6–7.............	Washington, D. C.	G. R. Chatburn, Univ. of Neb.
1918, June 26–29...........	Northwestern University, Evanston, Ill.	M. S. Ketchum, Univ. of Colo.
1918, December 6–7 †	Cambridge, Mass.	J. F. Hayford, Northwestern University.

* Meeting of Section E, Engineering Education, of the World's Engineering Congress, at which the S. P. E. E. was organized.

† Joint Meeting with the British Educational Mission to the United States. The meeting was called at the request of the Committee on Internatonal Relations of the American Council on Education.

1919, June 25–28	Johns Hopkins University, Baltimore, Md.	J. F. Hayford, Northwestern University.
1920, June 29–July 2	University of Michigan, Ann Arbor, Mich.	A. M. Greene, Jr., Rensselaer Polytechnic Inst.
1921, June 28–July 1	Yale University, New Haven, Conn.	M. E. Cooley, Univ. of Mich.
1922, June 20–23	University of Illinois, Urbana, Ill.	C. F. Scott, Sheffield Sci. School of Yale Univ.
1923, June 20–23	Cornell University, Ithaca, N. Y.	C. F. Scott, Sheffield Sci. School of Yale Univ.
1924, June 25–28	University of Colorado, Boulder, Colo.	P. F. Walker, Univ. of Kans.
1925, June 16–20	Union College, Schenectady, N. Y.	A. A. Potter, Purdue Univ.
1926, June 16–18	State University of Iowa, Iowa City, Ia.	G. B. Pegram, Columbia Univ.
1927, June 27–30	University of Maine, Orono, Maine.	O. M. Leland, Univ. of Minn.
1928, June 26–29	University of North Carolina, Chapel Hill, N. C.	R. L. Sackett, Penna. State College.
1929, June 19–21	The Ohio State University, Columbus, Ohio.	Dexter S. Kimball, Cornell University.
1930, June 26–28	Ecole Polytechnique, McGill University, Montreal, Canada.	R. I. Rees, American T. & T. Co.
1931, June 17–19	Purdue University, Lafayette, Ind.	H. S. Boardman, University of Maine.
1932, June 29, 30–July 1	Oregon State College, Corvallis, Ore.	H. S. Evans, University of Colorado.
1933, June 27–30	Stevens Hotel, Chicago, Ill.	R. A. Seaton, Kansas State College.
1934, June 19–23	Cornell University, Ithaca, N. Y.	W. E. Wickenden, Case School of Applied Science.
1935, June 24–27	Georgia School of Technology, Atlanta, Ga.	C. C. Williams, State University of Iowa.
1936, June 23–26	University of Wisconsin, Madison, Wis.	D. S. Anderson, Tulane University.
1937, June 28–July 2	Massachusetts Institute of Technology and Harvard University, Cambridge, Mass.	H. P. Hammond, Polytechnic Institute of Brooklyn.
1938, June 27–30	A. & M. College of Texas, College Station, Texas.	S. B. Earle, Clemson College.
1939, June 19–23	Pennsylvania State College, State College, Pa.	K. T. Compton, Mass. Inst. of Tech.
1940, June 24–28	University of California, Berkeley, Calif.	O. J. Ferguson, University of Nebraska.
1941, June 27–30	University of Michigan, Ann Arbor, Mich.	D. B. Prentice, Rose Polytechnic Institute
1942, June 29–July 2	New York City	A. H. White, University of Michigan.
1943, June 18–20	Illinois Institute of Technology, Chicago, and Northwestern University, Evanston, Ill.	H. T. Heald, Illinois Institute of Technology.

SUMMER SCHOOLS FOR ENGINEERING TEACHERS.

HARRY P. HAMMOND, *Director.*

1927—Engineering Mechanics, Cornell University.
1927—Engineering Mechanics, University of Wisconsin.
1928—Electrical Engineering, University of Pittsburgh, and Westinghouse E. & M. Company.
1928—Physics, Massachusetts Institute of Technology.
1929—Mechanical Engineering, Purdue University.
1930—Civil Engineering, Yale University.
1930—Engineering Drawing and Descriptive Geometry, Carnegie Institute of Technology.
1931—Chemical Engineering, University of Michigan.
1931—Mathematics, University of Minnesota.
1932—Economics, Stevens Institute of Technology.
1932—English, The Ohio State University.
1933—Mining and Metallurgy, University of Wisconsin.
1933—Conference of Administrative Officers, University of Wisconsin.

PAST OFFICERS.

Special Committee for Division E, Engineering Education, World's Engineering Congress, 1893.

IRA O. BAKER,* Chairman,
WM. R. HOAG, Secretary,
MORTIMER E. COOLEY,
HENRY T. EDDY,* Vice-Chairman,
C. FRANK ALLEN, Sec'y, *pro tem.*,
SAMUEL W. STRATTON,*
STORM BULL.*

PRESIDENTS.

DE VOLSON WOOD,* 1893–4,
GEORGE F. SWAIN,* 1894–5,
M. MERRIMAN,* 1895–6,
HENRY T. EDDY,* 1896–7,
JOHN B. JOHNSON,* 1897–8,
T. C. MENDENHALL,* 1898–9,
IRA O. BAKER,* 1899–1900,
FRANK O. MARVIN,* 1900–1,
ROBERT FLETCHER,* 1901–2,
CALVIN M. WOODWARD,* 1902–3,
C. FRANK ALLEN, 1903–4,
FRED W. McNAIR,* 1904–5,
CHARLES L. CRANDALL,* 1905–6,
DUGALD C. JACKSON, 1906–7,
CHARLES S. HOWE,* 1907–8,
FRED. E. TURNEAURE, 1908–9,
HENRY S. MUNROE, 1909–10,
ARTHUR N. TALBOT,* 1910–11,
WM. G. RAYMOND,* 1911–12,
WM. T. MAGRUDER,* 1912–13,
G. C. ANTHONY,* 1913–14,
ANSON MARSTON, 1914–15,
HENRY S. JACOBY, 1915–16,
GEORGE R. CHATBURN,* 1916–17,
MILO S. KETCHUM,* 1917–18,
JOHN F. HAYFORD,* 1918–19,
A. M. GREENE, JR., 1919–20,
MORTIMER E. COOLEY, 1920–21,
C. F. SCOTT, 1921–22, 1922–23,
P. F. WALKER,* 1923–24,
A. A. POTTER, 1924–25,
G. B. PEGRAM, 1925–26,
O. M. LELAND, 1926–27,
R. L. SACKETT, 1927–28,
D. S. KIMBALL, 1928–29,
R. I. REES,* 1929–30,
H. S. BOARDMAN, 1930–31,
H. S. EVANS, 1931–32,
R. A. SEATON, 1932–33,
W. E. WICKENDEN, 1933–34,
C. C. WILLIAMS, 1934–35,
D. S. ANDERSON, 1935–36,
H. P. HAMMOND, 1936–37,
S. B. EARLE, 1937–38,
K. T. COMPTON, 1938–39,
O. J. FERGUSON, 1939–40.
D. B. PRENTICE, 1940–41
A. H. WHITE, 1941–1942

VICE-PRESIDENTS.

SAMUEL B. CHRISTY,* GEORGE F. SWAIN,* 1893–4,
ROBERT H. THURSTON,* FRANK O. MARVIN,* 1894–5,
FRANK O. MARVIN,* CADY STALEY, 1895–6,
JOHN GALBRAITH,* JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL,* HARRY W. TYLER,* 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER,* 1898–9,
ROBERT FLETCHER,* CHARLES D. MARX, 1899–1900,
THOMAS GRAY,* ALBERT KINGSBURY, 1900–1,
STORM BULL,* CALVIN M. WOODWARD,* 1901–2,
JOHN J. FLATHER,* FRED W. McNAIR,* 1902–3,
CHARLES L. CRANDALL,* JAMES C. NAGLE, 1903–4,
CLEMENT R. JONES,* ELWOOD MEAD, 1904–5,
WILLIAM T. MAGRUDER,* JOHN P. JACKSON, 1905–6,*

* Deceased.

R. C. CARPENTER,* CHARLES S. HOWE,* 1906–7,
CLARENCE A. WALDO, WILLIAM G. RAYMOND,* 1907–8,
MORTIMER E. COOLEY, OLIN H. LANDRETH,* 1908–9,
ARTHUR N. TALBOT,* ARTHUR L. WILLISTON, 1909–10,
MILO S. KETCHUM,* WILLIAM KENT,* 1910–11,
G. C. ANTHONY,* F. B. GILBRETH,* 1911–12,
L. S. MARKS, F. W. SPERR,* 1912–13,
H. S. JACOBY, D. C. HUMPHREYS,* 1913–14,
H. H. NORRIS,* C. RUSS RICHARDS,* 1914–15,
G. R. CHATBURN,* F. H. CONSTANT, 1915–16,
HOLLIS GODFREY,* WM. M. THORNTON,* 1916–17,
JOHN F. HAYFORD,* IRA N. HOLLIS,* 1917–18,
JOHN T. FAIG, E. R. MAURER, 1918–19,
A. A. POTTER, F. P. McKIBBEN,* 1919–20,
T. U. TAYLOR,* H. S. EVANS, 1920–21,
H. J. HUGHES,* E. J. McCAUSTLAND,* 1921–22,
D. S. KIMBALL, F. G. HIGBEE, 1922–23,
H. S. BOARDMAN, O. J. FERGUSON, 1923–24,
R. S. KING, G. B. PEGRAM, 1924–25,
H. V. CARPENTER,* F. P. McKIBBEN,* 1925–26,
H. W. TYLER,* W. S. RODMAN, 1926–27,
C. E. MAGNUSSON,* THOS. E. FRENCH, 1927–28,
C. C. WILLIAMS, G. M. BRAÜNE,* 1928–29,
E. A. HITCHCOCK, ED. BENNETT, 1929–30,
C. FRANCIS HARDING,* R. A. SEATON, 1930–31,
D. S. ANDERSON, H. H. JORDAN, 1931–32,
PAUL CLOKE, H. S. ROGERS, 1932–33,
F. V. LARKIN, B. M. BRIGMAN,* 1933–34,
H. P. HAMMOND, GEO. C. SHAAD,* 1934–35,
P. H. DAGGETT, S. B. EARLE, 1935–36,
IVAN C. CRAWFORD, SADA A. HARBARGER,* 1936–37,
K. T. COMPTON, F. C. BOLTON, 1937–38,
G. W. CASE, M. L. ENGER, 1938–39,
R. W. SORENSEN, D. B. PRENTICE, 1939–40,
E. L. MORELAND, L. E. CONRAD, 1940–41,
H. T. HEALD, F. L. EIDMANN,* 1941–42.

TREASURERS.

STORM BULL,* 1893–5,
JOHN J. FLATHER,* 1895–9,
CLARENCE A. WALDO, 1899–1902,
ARTHUR N. TALBOT,* 1902–4,
FRED. P. SPALDING,* 1904–6,
ANSON MARSTON, 1906–7,
W. O. WILEY, 1907–42,
JAS. S. THOMPSON, 1942–.

SECRETARIES.

JOHN B. JOHNSON,* 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG,* 1899–1900,
HENRY S. JACOBY, 1900–2,
CLARENCE A. WALDO, 1902–4,
MILO S. KETCHUM,* 1904–6,
W. T. MAGRUDER,* 1906–7,
ARTHUR L. WILLISTON, 1907–9,
HENRY H. NORRIS,* 1909–14,
F. L. BISHOP, 1914–.

ASSISTANT SECRETARIES.

L. H. HARRIS,* 1914–8,
NELL McKENRY, 1918–.

* Deceased.

ELECTIVE MEMBERS OF PREVIOUS COUNCILS.

Terms of Office Expired in 1894.

M. E. Cooley, H. T. Eddy,* W. F. M. Goss,*
W. R. Hoag, S. W. Robinson,* H. W. Spangler,*
R. H. Thurston.*

Terms of Office Expired in 1895.

H. T. Bovey,* W. H. Burr,* O. H. Landreth,*
Mansfield Merriman,* W. G. Raymond,* G. F. Swain,*
De Volson Wood.*

Terms of Office Expired in 1896.

I. O. Baker,* Storm Bull,* S. B. Christy,*
John Galbraith,* J. B. Johnson,* F. O. Marvin,*
C. D. Marx.

Terms of Office Expired in 1897.

H. T. Eddy,* J. J. Flather,* J. P. Jackson,
Albert Kingsbury, L. S. Randolph, S. W. Robinson,*
R. H. Thurston.*

Terms of Office Expired in 1898.

C. F. Allen, C. L. Mees,* Mansfield Merriman,*
J. M. Ordway, W. G. Raymond,* Cady Staley,
R. S. Woodward.*

Terms of Office Expired in 1899.

Arthur Beardsley,* Robert Fletcher,* John Galbraith,*
William Kent,* T. C. Mendenhall,* W. H. Schuerman,*
M. E. Wadsworth.*

Terms of Office Expired in 1900.

Storm Bull,* L. G. Carpenter,* Albert Kingsbury,
F. O. Marvin,* R. B. Owens,* R. L. Sackett,
R. H. Thurston.*

Terms of Office Expired in 1901.

T. N. Drown,* M. A. Howe, I. N. Hollis,*
Gaetano Lanza,* P. C. Ricketts,* R. G. Thomas,*
C. M. Woodward.*

Terms of Office Expired in 1902.

Brown Ayres, G. W. Bissell, J. J. Flather,*
W. T. Magruder,* F. W. McNair,* J. M. Porter,*
A. J. Wood.*

Terms of Office Expired in 1903.

C. F. Allen, D. C. Jackson, N. C. Ricker,
J. P. Brooks, Edgar Marburg,* A. L. Williston,
J. C. Nagle.

* Deceased.

Terms of Office Expired in 1904.

W. F. M. Goss,* | Thomas Gray,* | D. C. Humphreys,*
O. H. Landreth,* | W. G. Raymond,* | L. E. Reber,
L. S. Randolph.

Terms of Office Expired in 1905.

Wm. Esty,* | L. J. Johnson, | W. M. Towle,
H. S. Jacoby, | Elwood Mead, | J. L. Van Ornum,
Edward Orton, Jr.*

Terms of Office Expired in 1906.

John Galbraith,* | Charles S. Howe,* | Walter M. Riggs,*
Frederick P. Spalding,* | Henry W. Spangler,* | Fred. E. Turneaure,
Herman K. Vedder.

Terms of Office Expired in 1907.

Thomas Gray,* | James C. Nagle, | William G. Raymond,*
Louis E. Reber, | Arthur N. Talbot,* | Clarence A. Waldo,
Arthur S. Woodward.*

Terms of Office Expired in 1908.

Victor C. Alderson, | Arthur H. Ford,* | H. P. Talbot,*
Francis C. Caldwell, | Henry S. Munroe,* | A. L. Williston,
Frederick W. Sperr.*

Terms of Office Expired in 1909.

Charles F. Burgess,* | John F. Hayford,* | Thomas W. Palmer,
Arthur M. Greene, Jr., | Milo S. Ketchum,* | Joseph A. Thaler,*
Henry H. Norris.*

Terms of Office Expired in 1910.

Fred W. Atkinson, | Walter B. Russell,* | William S. Franklin,*
Mortimer E. Cooley, | William Kent,* | Charles F. Scott,
Harold B. Smith.*

Terms of Office Expired in 1911.

L. P. Breckenridge,* | Lewis J. Johnson, | William G. Raymond,*
Thomas Gray,* | W. T. Magruder,* | Herman Schneider,*
Clarence A. Waldo.

Terms of Office Expired in 1912.

Frederick A. Goetze,* | H. Wade Hibbard,* | Edw. R. Maurer,
Frank H. Constant, | John H. Leete,* | John C. Ostrup,
Chas. Russ Richards.*

Terms of Office Expired in 1913.

C. H. Benjamin,* | E. E. Brydone-Jack, | John F. Hayford,*
G. W. Bissell, | W. H. Creighton, | C. Russ Richards,*
H. W. Tyler.*

Terms of Office Expired in 1914.

J. E. Boyd, | F. L. Emory, | J. A. L. Waddell,*
C. H. Crouch, | C. E. Magnusson,* | A. J. Wood,*
H. H. Stoek.*

* Deceased.

Terms of Office Expired in 1915.

F. L. Bishop, O. P. Hood,* W. B. Snow,*
G. R. Chatburn,* G. D. Shepardson,* J. C. Tracy,
F. P. McKibben.*

Terms of Office Expired in 1916.

John F. Hayford,* F. P. Spalding,* P. F. Walker,*
M. S. Ketchum,* A. S. Langsdorf, S. M. Woodward,
H. W. Tyler.*

Terms of Office Expired in 1917.

R. H. Fernald,* A. M. Greene, Jr., D. C. Miller,*
A. H. Fuller, E. V. Huntington, W. M. Riggs,*
V. Karapetoff.

Terms of Office Expired in 1918.

L. P. Breckenridge,* C. H. Crouch, F. P. McKibben,*
C. L. Cory, O. P. Hood,* G. D. Shepardson,
J. B. Whitehead.

Terms of Office Expired in 1919.

A. H. Blanchard, T. E. French, F. G. Higbee,
W. H. Browne, Jr., R. W. Gay, E. J. McCaustland,*
A. A. Potter.

Terms of Office Expired in 1920.

T. U. Taylor,* C. J. Tilden, Frank Aydelotte,
K. G. Matheson,* C. F. Scott, W. E. Mott,
L. M. Hoskins.*

Terms of Office Expired in 1921.

Frederick Bass, O. A. Leutwiler, J. Raleigh Nelson,
C. Francis Harding,* C. R. Mann,* F. L. Pryor,
W. J. Risley.

Terms of Office Expired in 1922.

H. S. Boardman, E. F. Coddington, C. C. More,
F. C. Bolton, W. H. Kavanaugh,* E. H. Rockwell,
W. S. Rodman.

Terms of Office Expired in 1923.

J. F. Merrill, R. S. King, L. L. Thurstone,
W. H. Timbie, J. H. Felgar, C. C. Williams,
J. C. Tracy.

Terms of Office Expired in 1924.

P. H. Daggett, M. L. Enger, O. M. Leland,
J. H. Dunlap,* J. C. L. Fish, F. E. Giesecke,
Morris Knowles.*

Terms of Office Expired in 1925.

M. W. Alexander,* H. S. Evans, H. J. Hughes,*
Edw. Bennett, E. A. Hitchcock, C. E. Magnusson,*
G. C. Shaad.*

* Deceased.

Terms of Office Expired in 1926.

D. S. Anderson, W. N. Barnard, Hugh Miller, H. C. Berry, F. A. Fish, F. E. Seavey,* E. J. Babcock.*

Terms of Office Expired in 1927.

W. E. Brooke, H. H. Jordan, E. B. Norris, G. M. Butler, W. H. Kenerson, Harold Pender, W. E. Wickenden.

Terms of Office Expired in 1928.

G. M. Braune,* W. C. Hoad, C. V. Mann, B. M. Brigman,* J. A. Hunter,* C. H. Mitchell,* R. I. Rees.*

Terms of Office Expired in 1929.

Sada A. Harbarger,* E. R. Hedrick,* R. A. Seaton, W. K. Hatt, J. J. Richey, J. W. Votey,* S. M. Woodward.

Terms of Office Expired in 1930.

J. M. Bryant, S. S. Edmands,* A. C. Lanier,* S. B. Earle, H. P. Hammond, C. M. McKergow, D. B. Prentice.

Terms of Office Expired in 1931.

Paul Cloke, R. C. Disque, H. S Rogers, C. S. Coler, T. M. Focke, C. H. Warren, J. J. Wilmore.

Terms of Office Expired in 1932.

I. C. Crawford, R. C. H. Heck, W. C. Huntington, C. R. Dooley, H. H. Higbie, N. C. Riggs, W. H. Timbie.

Terms of Office Expired in 1933.

L. E. Akeley, W. E. Farnham, T. J. Hoover, R. E. Doherty, Augustin Frigon, F. V. Larkin, J. E. McDaniel.

Terms of Office Expired in 1934.

L. E. Conrad, A. M. Dudley, F. L. Eidmann,* B. G. Elliott, A. E. Norton,* G. A. Stetson, E. R. Wilcox.

Terms of Office Expired in 1935.

W. M. Cobleigh, F. E. Johnson, C. W. Park, H. B. Dirks, Morland King, A. P. Poorman, Harry Rubey.

Terms of Office Expired in 1936.

F. E. Ayer, J. B. Finnegan, B. R. Van Leer. K. T. Compton, W. N. Gladson, H. B. Walker, C. H. Willis.

* Deceased.

Terms of Office Expired in 1937.

G. P. Boomsliter, C. E. Davies, C. L. Eckel,
G. W. Case, H. N. Davis, P. T. Norton,
W. T. Ryan.*

Terms of Office Expired in 1938.

J. W. Barker, A. B. Domonoske, T. H. Morgan,
M. M. Boring, L. E. Grinter, S. C. Ogburn,
F. L. Plummer.

Terms of Office Expired in 1939.

S. W. Dudley, H. J. Gilkey, F. W. Marquis,
O. W. Eshbach, E. A. Holbrook, R. W. Morton,
R. L. Sweigert.

Terms of Office Expired in 1940.

G. F. Eckhard, F. M. Feiker, C. E. MacQuigg,
D. S. Elliott, S. C. Hollister, F. B. Seely,
A. H. White.

Terms of Office Expired in 1941.

H. H. Armsby, Louis Mitchell, W. B. Plank,
H. T. Heald, C. A. Mockmore, J. S. Thompson,
R. B. Wiley.

Terms of Office Expired in 1942.

K. H. Condit, V. M. Faires, C. L. Kinsloe,
R. C. Ernst, H. A. Fisher, L. G. Straub,
B. M. Woods.

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* Deceased.

CONSTITUTION.

ARTICLE I.

NAME AND OBJECTS.

1. The name of this organization shall be the Society for the Promotion of Engineering Education.

2. The objects of this Society shall be the promotion of the highest ideals in the conduct of engineering education with respect to administration, curriculum, and teaching work, and the maintenance of a high professional standard among its members. The means to this end shall include educational research, the holding of meetings for the reading and the discussion of professional papers, and the publication of papers, discussions, and communications as may seem expedient.

ARTICLE II.

MEMBERSHIP.

Membership in the Society shall be of two general classes, Institutional and Individual.

Institutional members shall be of two classes, active and associate. The active institutional members shall be recognized institutions giving baccalaureate or equivalent degrees for curriculums in engineering, and distinguished national professional engineering societies. Associate members shall be other educational institutions giving instruction in engineering. Institutional members shall be entitled to representation at all meetings of the Society or its divisions by regularly appointed delegates, one for each institutional member concerned.

Individual membership shall be of two classes, Active and Honorary. It shall comprise those persons who occupy or have occupied responsible positions in the work of engineering instruction, engineering practitioners, and other persons interested in engineering education.

Honorary members of the Society shall be such persons as may be recommended by unanimous vote of the Council in a letter ballot to be taken by the Secretary on the recommendation of twenty members of the Society in the manner provided hereinafter for proposals for individual members. Councilors not heard from within one month from the date of mailing the ballots will be counted in favor of the candidate. Honorary members shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

A member in good standing may become a life member, exempt from all future payments for dues, by a single payment of an amount equal to twenty times the annual dues. Such payments received by the Society shall be placed in a separate fund known as the Life Membership Fund. The interest earned on this fund shall be used as current income.

An individual member who has been in good standing for twenty-five years or more, who has reached the age of 65 years, and who has retired from active professional life, may, upon written request, be designated as a life member by vote of the Council, and shall thereafter be exempt from the payment of dues.

The name of each candidate for active individual membership shall be proposed in writing to the Secretary by two members by whom the candidate

is personally known. The proposal shall state the qualifications on which it is based. The name of a candidate for institutional membership shall be proposed by any member familiar with the work of the institution, on receipt of an application signed by a responsible officer thereof. An affirmative letter ballot of three-fourths of those members of the Council whose votes reach the Secretary within one month from the time of sending out the name of the candidate shall elect. Such letter ballot elections, occurring before February 1, shall be credited to the previous annual meeting and dues shall date from that time; elections occurring after February 1 shall be credited to the next annual meeting and the dues for the remainder of the year shall be one-half the annual dues.

ARTICLE III.

Dues.

1. There shall be no admission fee.
2. The annual dues shall be as stated in the By-Laws.
3. Dues are payable in advance at the time of the annual convention, and become delinquent at the end of the fiscal year for which they are assessed. Dues of new members are payable at the time of election, and become delinquent at the end of the fiscal year within which the members are elected.
4. Members in arrears one year shall be retained on the roll of the Society, but shall not receive publications until such time as all arrearages are paid. Members in arrears two years, and who have been duly notified by the Secretary, shall be dropped from the roll of the Society until such arrearages are paid. The Secretary shall notify all members in arrears one month previous to the close of the fiscal year. The fiscal year shall terminate on the thirtieth day of June.

ARTICLE IV.

Officers.

There shall be a President, a First Vice President, and a Second Vice President, each to hold office for one year. There shall be a Secretary and a Treasurer, both to be appointed by the Council. In case of a vacancy in the office of President, the First Vice President shall succeed to that office. In case of a vacancy in the office of First Vice President, the Second Vice President shall succeed to that office.

ARTICLE V.

Council.

1. The Council of the Society shall consist of twenty-one elective members, one-third of whom shall retire annually, and the officers and the past presidents of the Society.
2. Any individual member of the Society shall be eligible to election to the Council, provided that not more than one elective member shall be from the faculty of any one institution.
3. The elective officers and members of the Council shall continue in office for a period of ten (10) days after their successors shall have been elected.

ARTICLE VI.

Election of Officers and Members of the Council.

1. The President, the two Vice Presidents, and one-third of the elective members of the Council shall be elected each year from the individual membership by ballot of the Society at the annual meeting.

2. There shall be a Nominating Committee consisting of the past presidents, the members of the Council retiring the following year, and one member of the Society from each Section, who shall have been elected for a term of one year at a regularly called meeting of the Section and duly certified to the Secretary of the Society before May 15. If, however, the total number of committee members attending any meeting of the Committee for official action be less than five, the President shall appoint a sufficient number to form a committee of five. The Committee shall report to the Society, at the business session provided therefor in the program, its nominations of officers for the ensuing year and of councilors for three-year terms and for any incomplete terms necessary to fill vacancies.

The senior Past President present at the opening of the committee meeting shall serve as its chairman.

Members of the Council who are serving the first year of their terms shall be invited by the Secretary to attend the meetings of the Nominating Committee as observers without voice.

By means of a form to be printed in THE JOURNAL OF ENGINEERING EDUCATION or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for officers and for the Council. These names, on the form provided, shall be sent to the Secretary of the Society not later than May 15; and, as soon thereafter as possible, the Secretary shall send the suggested names to all members of the Nominating Committee.

ARTICLE VII.

SECTIONS, BRANCHES AND DIVISIONS

1. A Section of the Society may be formed by members in two or more institutions, or by the members within a prescribed territory. A Section may be formed in any locality by a temporary organization which shall become a duly authorized section of the Society upon the approval of the Council. Sections may determine their own form of organization, but shall operate in conformity with the Constitution and the By-Laws of the Society and shall make a report of their proceedings to the Secretary of the Society. Sections shall be self-sustaining.

2. A Branch may be formed in any institution by a temporary organization which shall become a duly authorized Branch of the Society upon approval by the Executive Committee. Branches may determine their own form of organization, but shall operate in conformity with the Constitution and the By-Laws of the Society and shall make a report of their proceedings to the Secretary of the Society. Branches shall be self-sustaining.

Branches may coöperate with, or be a part of, other organizations having the same general purposes as this Society. The general purpose of Branches is to extend the interest in, and the discussion of, questions relating to the teaching of engineering students and to bring to the Society at large, through its publications, the activities in all institutions that will be serviceable to the members of the Society.

3. Papers and discussions presented before Sections or Branches shall be the property of the Society and may be published as Society proceedings if authorized by the Publication Committee. Permission to publish elsewhere may be granted by the Council on condition that the Society receives proper credit.

4. When approved by the Council, Divisions may be formed by any group of members for the consideration of questions which relate particularly to that group.

ARTICLE VIII.

Meetings.

There shall be at least one annual meeting at such time and place as the Society at the preceding meeting, or the Council, if the Society does not act, may determine. There shall be sectional and branch meetings as the members of the different sections and branches may determine.

ARTICLE IX.

Publications.

1. The formal publications of the Society shall be a monthly journal to be published from September to June, inclusive, and a year book. The *Journal* shall contain the proceedings of the annual convention, and such other pertinent papers as may be submitted to, and approved by, the Publication Committee. A bound volume of the *Journal* for each current year shall constitute the *Proceedings* of the Society.

2. Each individual member, not in arrears, shall receive the *Journal*. Each institutional member shall be furnished with two copies of the *Journal* and two copies of the *Proceedings* of the Society.

Volumes of the *Proceedings* will be sold to members who subscribe for them at a cost to be determined each year by the Executive Committee. Subscriptions for the *Proceedings* must be received in advance by the Secretary on or before October 15 of each academic year.

ARTICLE X.

Amendments.

This Constitution may be amended by a two-thirds vote of those present at any regular meeting of the Society, provided that all members have been notified of the proposed amendment by notices mailed from the Secretary's office at least 30 days prior to the regular meeting at which action is had, and provided that the amendment shall have been approved by the Council by a two-thirds vote of the members voting by letter or voice.

BY-LAWS OF THE SOCIETY AND RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange for the annual meeting and to prepare a program for it.

Second. The President, the two Vice-Presidents, the Secretary, and the Treasurer shall constitute an Executive Committee which shall have charge of all matters relating to the expenditure of money of the Society, the making of contracts, the approval of bills, and also during the period between the meetings of the Council shall have charge of other business affairs of the Society.

Third. Expenditures of money may be made only in accordance with a definite appropriation or by direct vote of the Executive Committee.

Fourth. The annual dues shall be $5.00 for individual members, and $15.00 for institutional members.

Fifth. Reading of papers shall be limited to fifteen minutes each, or to such other time as may be designated by the Program Committee, and abstracts

of papers of about three hundred words shall be printed when practicable, and distributed in advance to the members.

Sixth. The time occupied by each person in the extemporaneous discussion of any paper shall not exceed five minutes.

Seventh. The President, the Secretary, and the retiring president shall constitute a Publication Committee, of which the Secretary shall be chairman, to edit and to have charge of the publication of the monthly *Journal*.

Eighth. The subscription price of the *Journal* shall be three dollars per year, payable in advance.

Ninth. Any educational institution which has one or more of its curriculums accredited by the Engineers' Council for Professional Development shall be considered as "recognized" within the meaning of the constitutional requirement for active institutional membership, and no other educational institution within the United States or its territorial possessions shall be so considered.

Tenth. Any engineering degree-granting educational institution in continental North America, outside of the United States, shall be considered as "recognized";

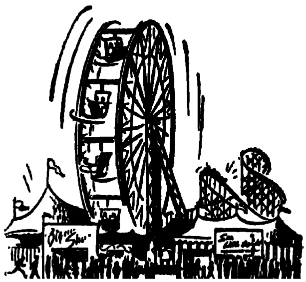
(*a*) If one or more of its engineering curriculums have been accredited by an agency whose standards are adjudged by the Council of the Society to be not lower than those of the Engineers' Council for Professional Development, or

(*b*) If no suitable accrediting agency is available to appraise its engineering curriculums, but one or more of these curriculums are adjudged by the Council of the Society, upon satisfactory evidence, to meet standards not lower than those of the Engineers' Council for Professional Development.

Eleventh. Any Junior College or other educational institution giving instruction which is adjudged by the Council of the Society, upon satisfactory evidence, to be substantially equivalent to the first two years of one or more curriculums accredited by the Engineers' Council for Professional Development shall be considered as among those institutions "giving instruction in engineering" within the meaning of the constitutional requirement for associate institutional members.

Twelfth. Additions or amendments may be made to these By-Laws at any regular meeting of the Society by a two-thirds affirmative vote of the membership present at the business session, provided that the additions or amendments shall have been approved by a two-thirds affirmative vote of the Council membership in attendance at the meeting, and shall have been recommended by that body for adoption.

G-E Campus News



MERRY-GO-WHEEL

DEVICE that rotates in the manner of a combination merry-go-round Ferris wheel has been developed to ·d the drilling of marine gear cas- ; at a General Electric plant.

nown as a universal indexing trun- ı fixture, the device permits quick 'ing of the casings for drilling at any le in a full circle and on any plane. /ement is controlled by a push- on.

bout 110 holes must be drilled and 'ed in each of the casings. Formerly ook a crane to move the casings ich vary in weight from 1000 to ' lb) after each surface was drilled, every piece of work had to be set t least six times.

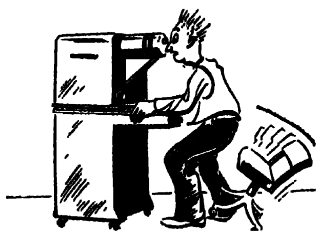
ow work is set up just once--on a : that can be turned completely nd in either direction with no more t than it takes to push a revolving '--and, amazingly enough, 24 to 32 's a week are saved.

THE BETTER TO SEE WITH

PARTICLES as small as one millionth of an inch--one thousandth of the diameter of a human hair—can be clearly seen with the new G-E electron microscope.

Developed by Drs. C. H. Bachman (Iowa State, '32) and Simon Ramo (U. of Utah, '33), the new instrument can magnify a specimen as much as 10,000 times and reveal the actual composition and structure of such minute things as dust and smoke particles.

Here's how it works: a beam of electrons inside a vacuum chamber passes



through the specimen, passes through an "electron lens," and produces a magnified picture on a fluorescent view screen. This image can then be photographed outside the tube and enlarged up to 100,000 times the original specimen.

The microscope, designed for use in small laboratories and war plants, is portable and operates on ordinary house current. General Electric Company, Schenectady, N. Y.

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WANTED: A PLAN FOR INDUSTRIAL TRAINING

By H. T. HEALD

President of the Society

It is now thoroughly recognized that the engineering colleges have two immediate and continuing responsibilities. The first of these is to furnish an adequate supply of men with technological training to the armed forces. The second, and equally important responsibility, is to maintain a continuous flow of trained personnel for war industry. Combined military and civilian requirements greatly exceed the capacity of the country's engineering schools. It is, therefore, of the utmost importance that the available personnel and the available training facilities be used to the highest degree of efficiency.

The new Army specialized training program and the Navy college training program are designed to meet the needs of the armed forces. Carefully prescribed curricula in the various engineering fields will produce officers and specialists with sufficient competence to perform military assignments. The engineering colleges are now actively engaged in preparing to make these programs operate with the maximum degree of effectiveness. Even though this work will involve many changes and adjustments of normal procedure, there is no question but that the engineering teachers of the country will be able to make an outstanding contribution to the war effort through these training programs.

The problem of how to maintain a continuous flow of trained manpower for war industry and essential civilian services has not yet been solved. ESMWT courses are making an important contribution through supplementary short term training, but this does not and cannot fulfill the need for fully trained graduate engineers.

Selective Service procedures now in operation permit the deferment of engineering students who have completed one year's college work. If present regulations are continued, some of the sophomores, juniors, and seniors not already committed to the armed forces, will be permitted to complete their courses in a civilian status. In the last few months, the Society for the Promotion of Engineering Education and most of the other national engineering societies have recommended the extension of deferment procedures to include engineering freshmen. This problem has been under consideration by the War Manpower Commission for many weeks, but no action has been taken in spite of the fact that all available evidence clearly

points to a continuing need for engineering graduates, which is several times the entire output of the engineering colleges. The effect of this delay is to cut off the supply at the bottom. If it is continued, engineering graduates available for war industry after 1944 will be limited to the small number who are physically unfit.

It is obvious that this small number will not keep the wheels of industry or civilian needs running. Some plan is immediately needed to maintain a continuous flow of essential engineering personnel. To delay in meeting this need is to court disaster, if the war is to continue beyond 1944.

There appear to be two possible plans for meeting these requirements. One is to enroll all able bodied men students in the military training programs, and assign back to civilian tasks those who may be needed in war industry. This appears to be an expensive and inefficient procedure. The needs of the military services themselves are so great that there is little likelihood of their releasing any considerable number of men who have been trained for military tasks. Furthermore, the curricula designed to prepare for military service are quite different from the training required for civilian occupations.

The second possibility, and the one which seems most practicable, is the establishment of an industrial training corps paralleling those of the Army and Navy. Such a corps could enroll young men not physically qualified for military service, women, and a sufficient number of the physically fit to meet the most essential needs. Some provision for financial assistance should be made in order that selection of students could be entirely on the basis of ability, but it seems unlikely that the entire cost of their education would need to be borne by the Government.

Physically fit students enrolled in such a program should be very carefully selected, on a quota basis, and could be provided temporary deferment under Selective Service. If, at any time, military requirements became more important than the needs of war industry, these men could be transferred to military service.

The general acceptance of such a plan by the public and by the students themselves would depend entirely upon the public understanding of the problem. Total war means just that. If total war is to be carried on, there are some types of service outside the armed services which are more important than being in the military branches. The American public can be made to realize this if it has the facts.

Immediate action is needed. The first step is the extension of temporary deferment to present engineering freshmen. This should be followed by the adoption of an adequate plan for industrial training. Until some such procedure is devised and placed in operation, we shall be gambling with the future of our country.

THE ENGINEERING COLLEGES' CONTRIBUTION TO ESMWT

By GEORGE W. CASE *

It is often remarked that those who are actively engaged in the operation of an extensive program, fail to appreciate the true magnitude of their contribution—that those deep among the trees do not envision the size of the forest. With this in mind, it seems appropriate to undertake an appraisal of the part which engineering colleges are playing in ESMWT.

Readers of the JOURNAL are aware that more than 897,000 men and women have been enrolled for EDT, ESMDT, and ESMWT courses since the start of the first program in 1940. Not all who are active in the current program may realize, however, that over 726,000, or 81 per cent, of these enrollments have been in engineering courses, and that by far the greatest training responsibility has been carried by engineering institutions. The continuation of that load is attested, moreover, by current enrollment statistics which show about three-quarters of active enrollments to be in engineering. Since active ESMWT enrollments have run at approximately 150 thousand, in recent months, active engineering enrollments can be estimated at between 110 and 115 thousand.

Perhaps the most significant appreciation of the contribution of the engineering colleges in this program may be obtained through a comparison of the instructional and supervisory load which they are carrying in ESMWT with that normally incident to the conduct of regular engineering curricula from which all accredited institutions graduate between 12 and 15 thousand engineers annually. Even though the average number of weekly contact hours per trainee in ESMWT is but 8, as contrasted with approximately 25 for students in regular engineering curricula, the instructional load compares with that of a full-time enrollment of 38,000 regular engineering students—a very large program indeed.

These figures do not tell the whole story, however, for the engineering colleges in the program have, simultaneously, done a magnificent job of pioneering in the development of new courses, suited to the potentialities of available trainees and to the specific personnel needs of wartime industries. This pioneering is the more

* Dean of the College of Technology, University of New Hampshire, absent on leave to serve as Director of Engineering, Science, and Management War Training in the United States Office of Education.

noteworthy because it has occasioned no diminution in the volume or decline in the quality of instruction offered to regular students of the participating institutions. The job has called for constant alertness, frequent revision of plans, and the closest possible relations with the management of war industries. It is noticeable that the greatest success in training, as measured by sustained student interest and by the placement and promotion of trainees, is intimately related to the extent of the coöperation between the colleges and the companies served. Representatives of both large and small war-production establishments have praised the program and the institutions repeatedly, expressing the conviction that they could not hope to duplicate elsewhere the training offered, and urging that it be continued and expanded.

With increasing engineering enrollments and faculties continually raided to fill all manner of technical and administrative posts in the prosecution of the war, the problem of finding, training, and supervising instructors for ESMWT courses has become increasingly difficult. Men from industry have brought a wealth of practical experience to bear on the planning of course content, but extensive coaching, instruction, and supervision have been required in many instances to prepare these men to handle classes on the college level and to insure that acceptable standards of instruction were maintained. The heavily-burdened faculties deserve great credit for the will and efficiency with which they have undertaken this additional task of training and supervision.

The growing need for the training of women in engineering techniques to supplement the dwindling supply of male technicians and to fill the staffs of expanding industries has further taxed the resourcefulness of our engineering colleges. The problem of inducing qualified women to undertake the training has been particularly difficult, possibly because women for years have been advised against enrolling in engineering courses. Nevertheless, many institutions, through effective publicity, have had marked success in the recruitment of women for ESMWT courses. Much exploration has been necessary to find means of determining the aptitudes of women with non-technical backgrounds for engineering work, and in the development of courses especially adapted to convert their talents for war production. It is significant that female registrations, during the three programs, have risen from 1 in 55 enrollments received to 1 in 4.

It is only after considering the time and energy that the staffs of institutions coöperating in ESMWT have expended in planning, organizing, and administering large institutional programs that one can truly comprehend the extent of their contribution.

In partial compensation, it is hoped that the faculties of institutions now conducting training in the program will find their experience and new contacts valuable in post-war revisions of curricula and teaching methods which may be necessary to train students for careers in fields that are now demanding technicians to fill wartime jobs. At present, however, we must continue to find men and women who have the necessary schooling and practical experience to meet the prerequisites of short courses that prepare for immediate service. ESMWT was established to accomplish this purpose and the evidence is clear that those participating in the program are equal to the task at hand.

ILLINOIS INSTITUTE OF TECHNOLOGY

By PAUL O. RIDINGS

Director of News Bureau

Illinois Institute of Technology was created in 1940 by the consolidation of Armour Institute of Technology and Lewis Institute, two old Chicago engineering schools each with a record of nearly 50 years of service. To perpetuate the names of these schools, the Institute now is organized into the Armour College of Engineering and the Lewis Institute of Arts and Sciences, as well as the Graduate School and the Evening Division.

The Institute makes use of both Armour and Lewis campuses, the former now being the south side campus of Illinois Tech, the latter the west side campus. War-time technical training demands, however, are such that these two campuses will not accommodate all the personnel at the Institute, and classes are now being held in eight different locations in Chicago.

Illinois Tech is dedicated to the service of the public and it accepts as a major contribution in this direction the stimulation of midwestern business and industry. Its inception was prompted by a desire to serve these public interests and to create for midwestern business and industry an important center for technological training and research. And, like every other engineering college, the Institute is now devoting its energies to helping to win the war.

Evidence of this is the more than 10,000 persons in training at Illinois Tech. The college enrollment numbers 4,555, the remainder of this number being trainees in various war programs.

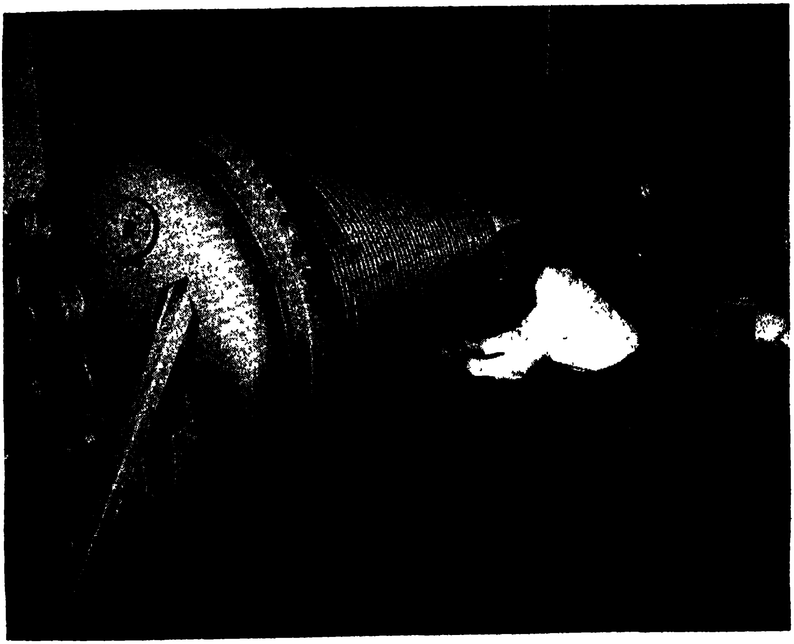
The Institute has a degree-granting curriculum in seven fields on the south campus and in six fields on the west campus. In the former, degrees are offered in architecture, chemical engineering, civil engineering, electrical engineering, fire protection engineering, industrial engineering and mechanical engineering.

On the west campus the degree of Bachelor of Science is offered in the following programs: Biology and pre-professional, industrial and food biology, business and industrial management, chemistry, home economics, humanities and public service.

One of Illinois Tech's outstanding educational features is the coöperative program wherein students alternate between working

in an industry representing their chosen field and attending school. Approximately 700 prospective engineers, chemists and management students were enrolled in this special program last year. The coöperative program is offered in mechanical engineering, chemistry, business administration and industrial management.

The Graduate School at Illinois Tech offers a program leading to the degree of Master of Science and Doctor of Philosophy in engineering and in scientific fields. It has been granting advanced

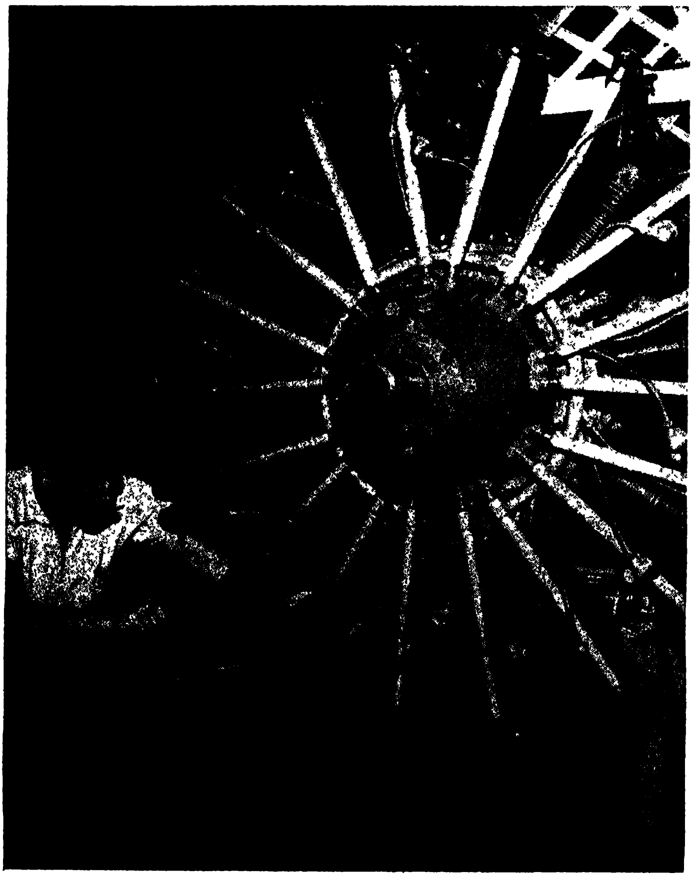


Dr. Rudolph W. Kanne, professor of physics at Illinois Institute of Technology, makes an adjustment of the voltage distribution range of the 1,500,000 volt atom smasher. In the foreground is shown the target end of the instrument and some of the pumping equipent to exhaust the accelerating tube.

degrees in all major fields of engineering as well as chemistry, physics, mathematics, mechanics and metallurgy. A hundred day school graduate students and several hundred evening students are candidates for advanced degrees.

The Fundamental Research program of the Institute is conducted under the sponsorship of the Graduate School. Graduate students are associated with this work in catalysis, heat transfer, spectroscopy, electronics, unit processes, mechanics, materials properties and other theoretical and laboratory investigations. The

recent installation of the first electron microscope in the Chicago area has made available unusual facilities for much of this research. Special projects have been sponsored by industry, by professional



An aeronautical engineering students at Illinois Institute of Technology makes a precise adjustment on a radial airplane engine in the Illinois Tech automotive-aeronautics laboratory.

In addition to the regular engineering students, the Institute has trained nearly a thousand aviation technicians in special war-training courses since the war opened.

associations and by government agencies. Emphasis has been placed upon those projects that seem especially appropriate to the objectives of an institute of technology as distinguished from a college of liberal arts.

The Institute's Evening program includes undergraduate work leading to a degree in any of the fields of study offered at the college. It is the policy of the Institute to give exactly the same courses day and evening taught by the same teachers, wherever possible, and thus to maintain identical standards in day and evening work.

Aside from training regular personnel for the scientific and engineering professions and conducting fundamental and industrial research, Illinois Tech is making extra contributions in its

Two engineering students at Illinois Institute of Technology are shown calibrating the rectangular weirs by the hook gage and weighing tanks in the hydraulic laboratory of the school.

training of war technicians. More than 26,000 have been trained in Engineering, Science and Management War Training courses, nearly a thousand of these being women. The Institute offers war training at no cost to students, expenses being paid by the government under the auspices of the U. S. Office of Education. In addition, Illinois Tech's signal corps training program will develop several thousand men for that branch of the armed forces.

Development plans at Illinois Institute of Technology call for the consolidation of all activities on one campus, the south campus,

in the future. The first of the several modern, functional buildings, designed by Ludwig Mies Van der Rohe, which will constitute the new campus, was recently dedicated. The Metals and Minerals Research Building of the Research Foundation, a quarter of a million dollar building, is the first completed unit in the building program.

Dr. James Thompson, chairman of the physics department of Illinois Institute of Technology, examines a slide while F. C. Breeden, graduate student, adjusts the controls on Illinois Tech's new $12,000 electron microscope.

Illinois Tech's electron microscope, which is the thirty-fourth such instrument in the nation and the only one in the Chicago area, is from 50 to 100 times more powerful than the strongest optical microscope.

Dr. Otto Zmeskal, assistant professor of metallurgy at Illinois Institute of Technology, is pictured examining steel for flaws on the 200 kilowatt X-ray tube in the X-ray laboratory of the nation's largest engineering school.

The laboratory, which is the only laboratory in the Midwest designed to train experts in radiographic inspection of metals and metallurgical welding and casting, was equipped at a cost of approximately $7000.

In addition to the use of the X-ray laboratory made by the metallurgic department, the laboratory is also used in the Engineering, Science and Management War Training program classes. A class of 25 men are in constant training in X-ray and radium testing in a special 10-weeks course, and women in the full-time ordnance inspection group of E.S.M.W.T. conclude their work in the laboratory.

An extensive program of industrial research is carried on by the Armour Research Foundation of Illinois Institute of Technology. Much of this work now consists of war projects. The Institute of Gas Technology, established in 1941 in coöperation with major American gas companies and gas appliance manufacturers, carries on graduate education and research of value to the gas industry.

NORTHWESTERN TECHNOLOGICAL INSTITUTE

By C. E. WATSON

Assistant Professor of Industrial Relations

The Technological Institute of Northwestern University was established in 1939 through a gift of $6,735,000 from the late Walter P. Murphy, chairman of the Standard Railway Equipment Manufacturing Company of Chicago.

The Institute has three main objectives: (1) to provide training in engineering for a select group of young men; (2) to provide industry with skilled workers and executives; and (3) to provide facilities for research in engineering and science.

The new buildings of the Institute, erected at a cost of $5,000,000, was dedicated on June 15 and 16, 1942, with impressive ceremonies attended by 1,000 representatives of American Industrial firms, scientific groups, and educational institutions.

The building consists of a central structure with six wings, and has a floor area aggregating about 10 acres. The central part is occupied by the main auditorium lecture rooms, library, student lounges, and main offices. The six wings house the departments of physics and chemistry of the University, and the departments of chemical, civil, mechanical, and electrical engineering of the Institute.

The keystone of the Institute's program is the coöperative plan whereby students alternate three months of study in the classroom with an equal period of work in industry. The Institute operates on a normal five-year curriculum. The student spends his first year on the campus in class-room study, thereafter alternating each quarter between the classroom and a job in industry. Half of the class thus remains in college while the other half is at work. The next quarter these groups are shifted. This alternating schedule continues until the spring quarter of the final year, when the entire class is brought back to the campus.

Seventy-five large firms, located in twelve different states, are now coöperating with the Institute. The industrial concerns afford the students opportunity for direct experience and in return these firms are provided with young men who have been carefully selected and taught.

The war has furnished the Institute with an early opportunity to demonstrate the thesis of its founder that the greatest contribu-

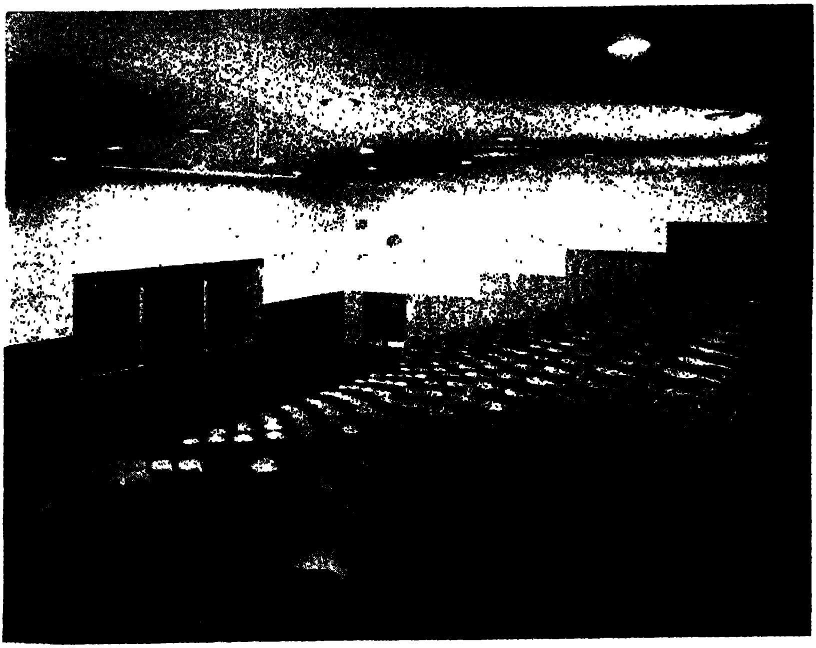
tion he could make to the welfare of America would be the establishment of a school for training engineers and carrying on research. Extending for 500 feet along the shores of Lake Michigan, the huge Lannon stone building is now employed not only as a training center for the technicians needed by the Army and the Navy, and in the equally important work of providing new experts for the defense industries, but as the seat of a large amount of confidential government research intimately connected with the war.

Heat Power Laboratory in the Department of Mechanical Engineering.

The new building contains more than $1,000,000 worth of the most modern scientific equipment. "Bomb rooms" with twelve-inch walls to guard against explosions from experimentation, an artificial river to test boat models, and vibrationless rooms are among the features. Opportunities for special types of investigation are afforded by six cold rooms in one of which the temperature may be driven down to 75 degrees below zero. In addition, huge pieces of equipment are available to test materials, including a two-and-one-half story transverse-universal testing machine, which is capable of exerting a pressure of one million pounds at the

center of a fifty-five foot truss. A 1,500,000 volt "lightning" generator tops off the list of giant machines in the building.

An example of the facilities which are available to students and to research workers is provided by the department of physics. This department has a special laboratory of explosion-proof construction in which it is possible to produce six gallons of liquid air and two-and-one-half gallons of liquid hydrogen an hour. Cold rooms, x-ray rooms, electrical laboratories, spectroscopic laboratories and heat and pyrometry laboratories comprise some of the



Large Lecture Room in the Technological Institute of Northwestern University.

important facilities for teaching and research. One of the features of the department is a sound-proof room which is being used for theoretical research. The room which is inside another concrete room is mounted on rubber. It weighs 50 tons and its walls are covered with 18 layers of muslin which absorb 98 per cent of airborne sound and mechanical vibrations from the outside.

At the present time the Institute has an enrollment of approximately 800 full-time students, who have been carefully selected on the basis of scholarship, engineering aptitude, and other qualifications. Under the coöperative plan, these students serve internship periods in industry of three months each, alternating them

with equal periods of regular academic work on the campus. Besides gaining practical experience in this way, the students are also making important contributions to the defense industries by which they are employed.

The Institute is coöperating directly with the Army and Navy in a number of ways. Courses for the Army Signal Corps Officers' Training School and the Naval Radio Operators' School are given in the Institute and make use of Institute facilities. Approximately 200 qualified men with engineering backgrounds are receiv-

The Cement Laboratory in the Civil Engineering Department of Northwestern University.

ing training in the Army Signal Corps School. Graduates of the course are commissioned as second lieutenants in the Signal Corp Reserves.

The Naval Radio Operators' School, which has an enrollment of approximately 1,000 sailors, carries on a four-month course to qualify men as naval radio specialists. Instruction is given by faculty members in the Technological Institute.

In order to aid in the training of personnel for war industries many tuition-free courses, sponsored by the Office of Education, have been given by the Institute. These college level courses pro-

vide training in the fundamentals of industrial engineering. Approximately 5,000 persons have already received training at the Institute in such fields as production processes, industrial organization, industrial accounting, drawing and specifications, and supervisory techniques.

The Institute has coöperated with the civilian defense program by providing a special course of free classes for civilians and air raid wardens in which incendiary bomb techniques, gas protection, public health problems created by bombs, transportation during raids, and kindred problems were analyzed. All phases of bomb-

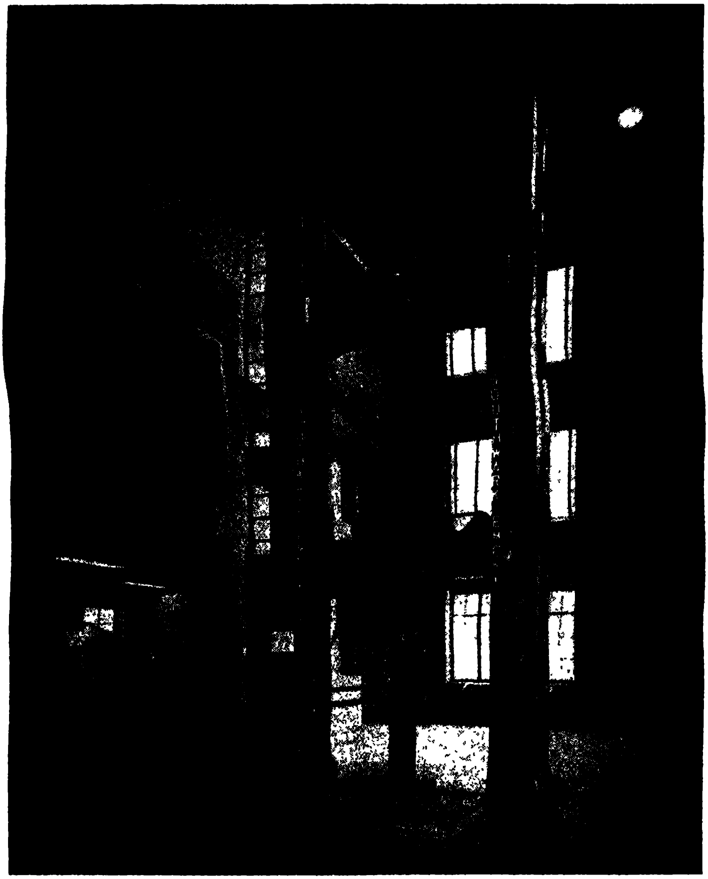
The Technological Institute of Northwestern University, Evanston, Ill.

ing raid protection were covered by Institute Instructors, who were in charge of the class, and by guest lecturers.

Classes in connection with the Civil Aeronautics Administration are also provided by the Institute. The CAA program has to date given training to 735 flying students. At present 140 aviation cadets of the Navy are being given flying instruction and ground work under Dr. Everett Edmondson, director of aeronautics of the Institute.

Had Mr. Murphy planned the Institute as a contribution to the war effort, it could not have been more timely. According to Ovid W. Eshbach, dean of the Institute, approximately 5,000 people are taking, in the laboratories and classrooms of the Institute, work that is directly or indirectly related to the war effort. Not only is

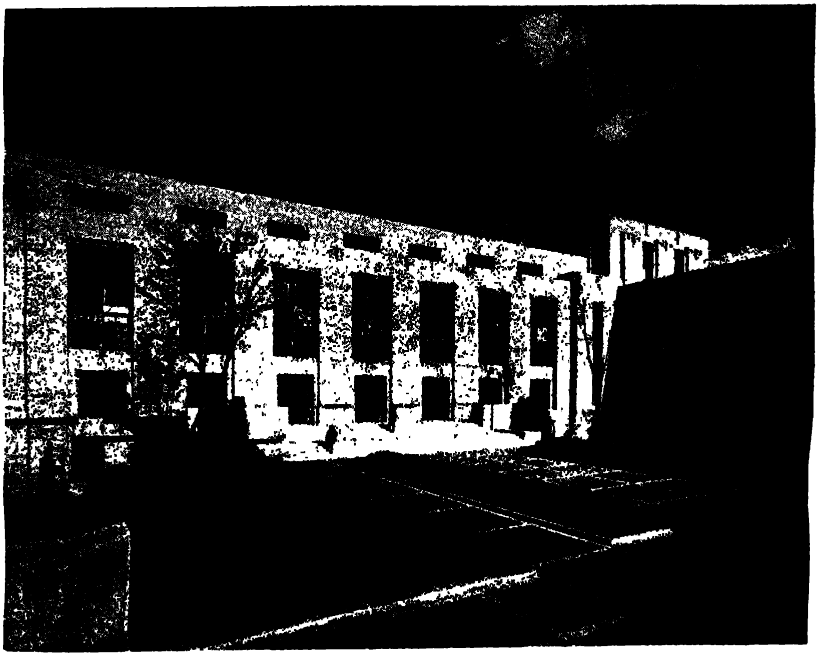
the Institute carrying on the programs listed above, but it is also engaged in a large number of projects involving confidential research for the government, utilizing the up-to-date equipment of the Institute for this purpose. Although the nature of these projects cannot be divulged, it is certain that their successful completion will be of great value in peace as well as war.



"1,000,000-POUND TESTING MACHINE"

Crushing 18-inch thick concrete or gently cracking egg shells are equally easy for the two-and-a-half story, 1,000,000-pound testing machine in the new Technological Institute of Northwestern University, Evanston, Illinois. This piece of equipment, known as a transverse-universal testing machine, is used to study the structural performance of large beams, girders, and columns. It can apply a pressure of 1,000,000 pounds on girders or rigid frames up to 55 feet in length. Here it is shown, ready to test the strength of a concrete column 6 feet high and 18 inches in diameter.

The financial future of the Institute is assured by a recently announced bequest in "excess of $20,000,000" from the estate of Walter P. Murphy, who died on December 16. His will specified that this sum should be used to develop, maintain, and operate the Institute. Although he expressed the desire that as much as possible of the principal should be held intact and used for endowment



Entrance court of the $5,000,000 building of the new Technological Institute of Northwestern University. More than 500 feet wide and 347 feet deep, it has a floor area of 423,000 square feet—which makes it one of the largest educational buildings in the world. The exterior is of Lannon stone, with Indian limestone trim. Modern Gothic architecture is used to conform with other new buildings on Northwestern's Evanston campus. It consists of a four-story central structure with six wings, and has the appearance of two letter E's placed back to back. It contains more than 350 rooms, used by the departments of physics, chemistry, and civil, mechanical, electrical, and chemical engineering.

of the Institute, he at the same time empowered the trustees to spend portions of the principal, and all or any part of the annual income, for additional buildings, equipment, professorships, research, and other purposes. The Institute may also, as a part of its operations, give instruction in science to other than engineering students of the University.

RECENT DEVELOPMENTS IN ARMY AND NAVY COLLEGE TRAINING PROGRAMS *

By HENRY T. HEALD, *President*,

Illinois Institute of Technology; President of the Society

I am glad to have an opportunity to discuss some of the recent developments in the utilization of the engineering colleges in the war. The officers and several committees of your Society have been almost continuously at work on these problems in the last few months. Plans are now sufficiently complete so that it is possible to predict, with at least a fair degree of accuracy, the general form which college education for war service is going to take.

It is not my purpose in this discussion to give any comprehensive coverage of all of the special activities of the engineering colleges in the war. You are already familiar with the important contributions which are being made by supplementary training programs under the auspices of the E.S.M.W.T.

You are of course aware of the war research work in engineering and scientific fields going on in many institutions. You are also familiar with some of the training programs being conducted on a contract basis for various branches of the military services. I *am* going to discuss the effect of the war on what we may call our normal full time programs in engineering education.

In order to do this let us review briefly the various steps in governmental policy which have been taken during the last year.

December 7, 1941, found the engineering schools already fairly well mobilized to make an effective contribution to the war. The Selective Service system was already in operation. Acceleration of courses had been widely discussed although not generally adopted. The demand for men with engineering training was extremely great and the E.S.M.W.T. program was almost a year old.

The declaration of war naturally quickened the desire of all colleges to organize for even more effective participation. One thousand college presidents met in Baltimore on January 3d and 4th, passed resolutions asking for more specific assignments, and then went home more confused than before.

The lowering of the draft age from 21 to 20, coupled with the increased need for men trained in essential fields, produced rather

* Presented at the meeting of the Middle Atlantic Section, S. P. E. E., Cooper Union, December 5, 1942.

general adoption of accelerated programs in a variety of forms. Efforts were begun to secure financial assistance for students in accelerated courses of study and for the colleges operating them. These efforts were generally unsuccessful although they did result in a student loan fund which came too late to be of any help during the summer term.

In the spring the Navy Department announced its new V1–V5–V7 reserve program. This was followed shortly afterward by the Army's Enlisted Reserve Corps for college students. The joint Army and Navy Personnel Board was appointed and succeeded in bringing some semblance of order out of the competitive recuriting programs in operation on college campuses. However, it is significant that the Army and Navy reserve programs continued to maintain essential differences in character, although neither was very realistic in requiring the type of training actually needed for military service.

In the meantime Selective Service procedures permitting the deferment of students in training for essential occupations were proving successful in maintaining a flow of graduate engineers for military service and war industries.

Growing dissatisfaction with the general mobilization of colleges and universities for war resulted in a second conference under the auspices of the American Council on Education, in Baltimore on July 15–16. More resolutions were passed. In the meantime the Chairman of the War Manpower Commission requested the U. S. Office of Education to prepare a comprehensive plan for the effective utilization of higher education in the war. The special committee appointed to prepare this plan submitted its report on July 10, and, on July 29, the Manpower Commission discussed the proposed plan and referred it to a subcommittee for further study. On August 20, the Manpower Commission released the approved report of this subcommittee in the form of a statement of policy which should guide any program for the utilization of colleges and universities. This statement, now widely publicized, was not an adoption of the report of the Office of Education Committee. Two points in this document are of particular significance: namely,

(1) "All able bodied male students are destined for the armed forces. The responsibility for determining the specific training for such students is a function of the Army and Navy."

(2) "Any plan for student war training must take into consideration the possibility that the Selective Service Act may be amended so as to lower the age of liability for service to 18 years."

At the same time, the Manpower Commission indicated that its Division of Professional and Technical Personnel under the direc-

tion of Dr. E. C. Elliott would "function as a central agency to advise with government departments and higher educational institutions concerned as to plans and procedures for the utilization of the facilities of the institutions and the adjustment of their programs for effective participation in the war effort." This division was also instructed to organize special committees representing the special interests of higher education and to work with the American Council on Education as an overall agency.

About the same time, the American Council on Education appointed a new Committee on Relationships of Higher Education and the Federal Government, under the chairmanship of President Day of Cornell University. This committee held its first meeting on August 31 and September 1, and offered its services to the joint Army and Navy Personnel Board and the War Manpower Commission. These offers were accepted and subcommittees were appointed to work with both agencies.

In the meantime the Army and Navy were proceeding with the college reserve programs and joint recruitment teams went into the field about September 15, 1942. It was of course already evident that these plans provided no satisfactory answer to the problems of the college student or of the military services. They were extremely vulnerable to criticisms of unfair discrimination in favor of the boy who could afford to go to college and they provided no machinery for the training of better qualified young men who might not be so fortunate financially. This problem became of increasing importance when it appeared evident that the Selective Service age would be lowered to 18.

On September 10, Secretary of War Stimson dropped a bombshell into the college world by announcing that enlisted reservists would be called to active duty at the end of the term in which they became of Selective Service age. At the same time the Navy indicated that it had no intention of making any radical changes in its announced college reserve plan.

At the meeting of the American Council on Education Committee on September 17–18, careful consideration was given to all the developments to date as well as to information obtained in numerous conferences with representatives of the Army and Navy and other government agencies. The committee recognized the need of an overall plan for college training for military service and war industry, but concluded that the tactical situation made such a plan impossible at this time. As a result the committee formulated a plan for an enlisted training corps in the Army, Navy, Marine Corps and Coast Guard.

In brief this plan provided the following:

(1) That a training corps for military service be established at designated colleges and universities, open to all male high school graduates or others of equivalent education over 17 years of age, who meet competitive standards, up to quotas to be established by the respective armed forces, selection of candidates for enlistment to be made by appropriate military authorities in coöperation with the institutions.

(2) Enlisted candidates may exercise choice in the selection of an institution within limits of quotas and establishment of programs by the armed forces.

(3) Enlisted candidates shall pursue year round curricula, extending four semesters or the equivalent in length, agreed upon by proper military and institutional authorities. Upon completion of this basic training, they may be assigned for further professional and specialized training.

(4) Enlisted candidates shall receive base pay and subsistence while attending colleges and universities as members of the corps.

This plan was transmitted to the War and Navy Departments and was made the basis for discussion in several conferences. In the meantime it became evident that the Army and Navy were at work on the formulation of similar plans which would make use of the facilities of colleges and universities. It became clear that the military services were thinking primarily in terms of training for the technical and professional fields, such training to be abbreviated as much as possible. It was also apparent that there would be certain essential differences in the plans adopted by the Army and Navy, notably that men assigned to the Army plan would be selected after the completion of 13 weeks basic training, while those accepted by the Navy would be admitted directly from high school.

Both the Army and Navy plans have now been completed in general form and have already been publicly referred to in statements by the President as well as by representatives of the War and Navy Departments. Both plans include provisions for a transition period which will provide for those students already enrolled in the enlisted reserve corps. More specific details of these new programs will be made public at an early date and until such a release is made I am not at liberty to disclose them.

Many details such as procedures for the selection of enlistees, courses and curricula, and methods for the selection of participating institutions are not yet fully developed. In connection with these phases the military agencies are drawing freely on experienced educators for advice and assistance.

The nature of modern war is such that a very large proportion of the men trained in these new programs must be fitted for work in engineering and scientific fields. The country's engineering colleges will, without doubt, be called upon to carry a large share of the load. Therefore, we as engineering educators are vitally interested in seeing this work organized in a successful fashion. The S. P. E. E., at the meeting of administrative officers recently held in Chicago, authorized the appointment of a special committee to work with the armed forces. This committee, working with the American Council on Education Committee, has already submitted the names of a panel of more than one hundred experts in the various special fields of engineering, from which the Army may choose consultants for the preparation of engineering curricula. The services of this committee will also be used by both the Army and Navy in connection with other pertinent problems.

The plans which I have been discussing have considerable merit. They will, if properly operated, permit the selection of the country's best qualified young men on a broad democratic basis, without regard to financial resources, and thus permit young men of superior ability to be trained for officers and specialists. This should meet adequately the needs of the military forces.

There is another aspect to this whole problem, namely, how are war industry's requirements for fully training engineering and scientific personnel to be met? Deferment procedures which are now in operation under the Selective Service System have permitted at least a portion of our graduates to go into war industry. With the lowering of the draft age to 18, nearly all of our engineering students will be in the Army unless Selective Service procedures are changed. The S. P. E. E. in common with several other engineering societies has recommended that provisions be made for the deferment of properly qualified engineering students in their freshman year. This recommendation is based upon the assumption that war industry will require a continuing supply of men with engineering training. Actual data on this point are difficult to obtain but all of us can testify to the tremendous demand for engineering graduates. National Headquarters of Selective Service have as yet taken no action on this problem. I am informed that they are awaiting information from the War Manpower Commission. I think this situation is crucial. It seems extremely unlikely that the demands of war industry can be met solely by the physically unfit or by the few women we may be able to persuade to enroll in engineering courses. Certainly, it seems to me, that until it can be clearly demonstrated that war industry is not

going to need young engineers, at least a reasonable number must be allocated for this purpose, in addition to those assigned to the military services.

In order to be really effective such a procedure would probably involve the establishment of an industrial training corps, with definite quotas and definite responsibilities to be met by the institutions and by the students. Unless some such plan is put in operation in the very near future the supply of engineers for war industry in 1943 and thereafter will be very small indeed.

This in general terms summarizes the situation as it stands today. Some features of the Army and Navy plans will not be to our liking. I am, however, convinced that they are entirely workable. The purpose of both plans is to train men as officers or specialists. The courses will be sound, fundamental college training in the engineering fields. Military aspects will be distinctly secondary. Problems of administration and housing should not be too difficult. The total number to be trained in engineering will compare favorably with our present enrollments.

I am sure that the engineering colleges will be able to make the adjustments necessary for the success of this program.

IMPORTANCE OF GRAPHICAL SOLUTION OF PROBLEMS IN MECHANICS

By L. M. SAHAG

Professor of Machine Design, Alabama Polytechnic Institute

In the design of structures and machines for determining the forces and their effect often it becomes necessary to use the graphic method, either as a check to the analytic method, or as the only direct method of obtaining the desired results. It is not intended here to draw a comparative picture between analytic and graphic methods, or in any way to criticize the present method of teaching the course of mechanics. But from the practical standpoint it is rather important to mention that the graphic solution of problems in mechanics is often more desirable by the engineers in industry for the following reasons: (1) By graphic method one can find more than the desired results; (2) it is engineer's or draftsman's method; (3) the results for all practical purposes will be accurate, and (4) the arrangement of forces and the shape of the frame not only make the graphic solution shorter, but a direct method.

The following examples illustrate a few interesting problems which show the usefulness and practical value of graphic method. Figs. 1 and 2 represent the same beam supported at both ends and carrying three non-parallel loads. In Fig. 1, R_1 and R_2 are determined by means of force and funicular polygons shown in dash lines. In order to determine the maximum bending moment the force and funicular polygons are modified, *i.e.* the ray or component 5 is made parallel to the beam. New force and funicular polygons are drawn in full lines. From these polygons the maximum bending moment is equal to $(AD - BF) \cdot h$, which should be the same as $(R_1 \times 10) - (30 \times 5.2)$.

In Fig. 2 the same results are obtained by taking the vertical components of 30 and 40 pounds inclined forces, and treating the problem as if made of parallel forces. In the force polygon, Fig. 2*b*, $a - d'$ is the sum of the vertical forces. For these forces the force and funicular polygons are first shown in dash lines, resulting R_1 and also the vertical component of R_2, and finally the actual R_2 represented by the line $e - d$. In order to obtain the exact value of the intercept, the force and funicular polygons are modified, and are shown in full lines. Y_0 is the maximum intercept which multi-

plied by h, the pole distance, will give the maximum bending moment. This product should be equal to, $(R_1 \times 10) - (25.9 \times 6)$.

Problems of this character can be found in actual work, for which the graphic solution will be found not only as satisfactory as

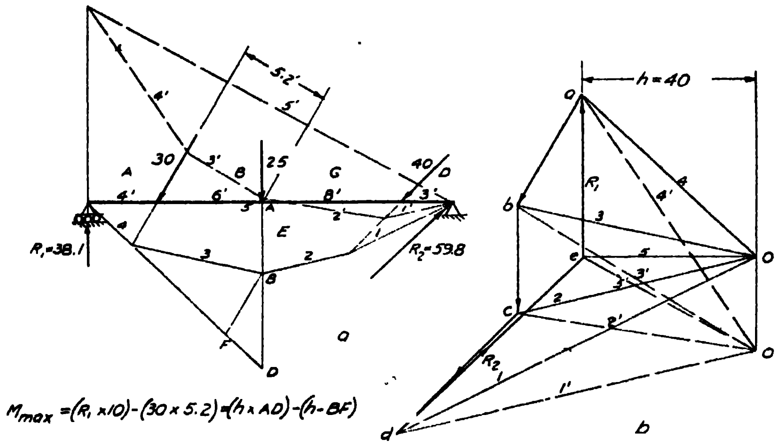


FIG. 1.

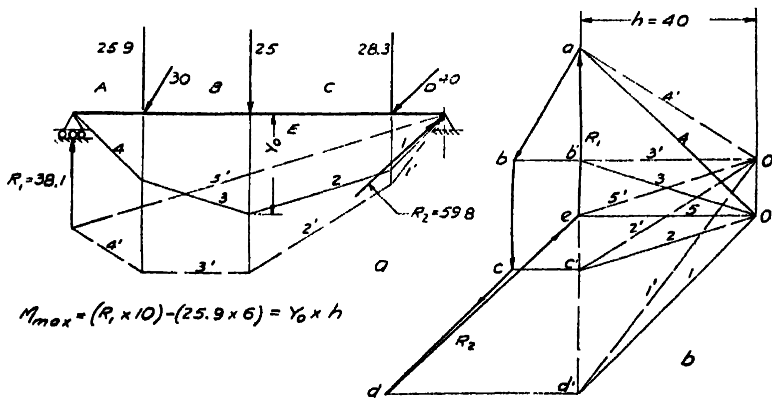


FIG. 2.

the analytic solution, but it will also display the real existing conditions which various loads may cause. For instance, shafts carrying non-coplanar, non-parallel loads, railroad axles equipped with roller or ball bearings, balancing problems, inertia forces, etc., are practical examples which can be solved very satisfactorily by graphic method.

Figure 3 illustrates a truss with the known forces and reactions,

R_1 and R_2 acting on the truss. It is desired to determine the stresses in members, 4, 5 and 6 by method of sections. For this, the right hand triangular section of the truss is chosen. Around this section there are three known forces, 2000, 1000 and 2620(R_2), and three unknown forces, 4, 5 and 6. All the known and unknown forces are in equilibrium. If we only had the known forces acting on the section, a force of 1500 pounds acting through point O will be needed to establish equilibrium. It will also be true that a force of the same magnitude will establish equilibrium with the unknown forces, but the direction of the latter will be opposite to that of the first.

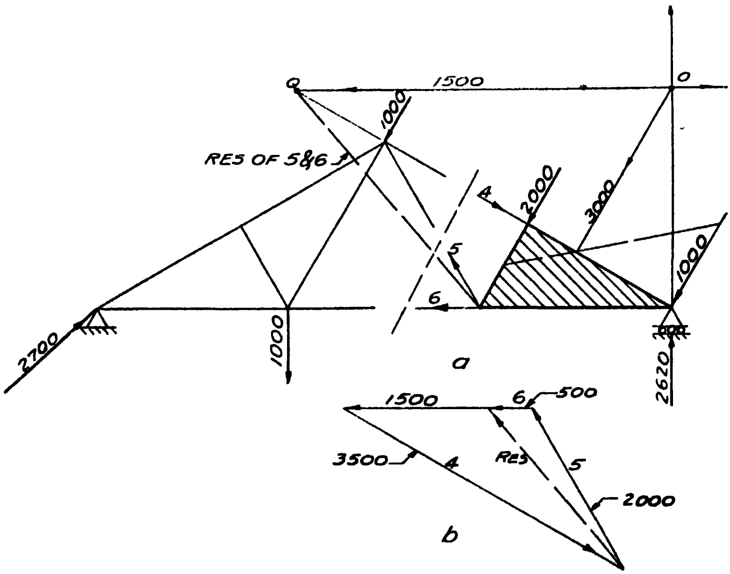


FIG. 3.

This in view, line of action of 1500 pounds, that of member 4, and the resultant of forces 5 and 6 are in equilibrium, and all act through point Q. The polygon Fig. 3b gives the values of 4 and the resultant of 5 and 6. The same figure also shows that 5 and 6 are the components of their resultant.

The graphic solution of method of sections can be applied to any problem. Its usefulness can be easily seen when forces acting on a frame are not parallel, or the frame itself is of such form that the actual direction of forces, as well as the members, do not form definite angles either with a horizontal or vertical line, analytically they become rather complicated problems to solve. In this case it will be found that once the direction of the forces are known, solu-

tions similar to that in Fig. 3 will give the desired results. In some problems the known forces around the section may result in a couple. This can easily be changed into another couple as that of the unknown forces, or stresses, remembering that the moment of one couple is equal to that of the second couple with respect to the same point.

Figure 4 represents a two member frame. This is solved analytically in the Applied Mechanics, H. F. Girvin. To solve it graphically each leg is assumed as a separate member supporting the given load and having the reactions at each end. Thus, the left leg carries 100 pounds and the reaction at B is in the direction

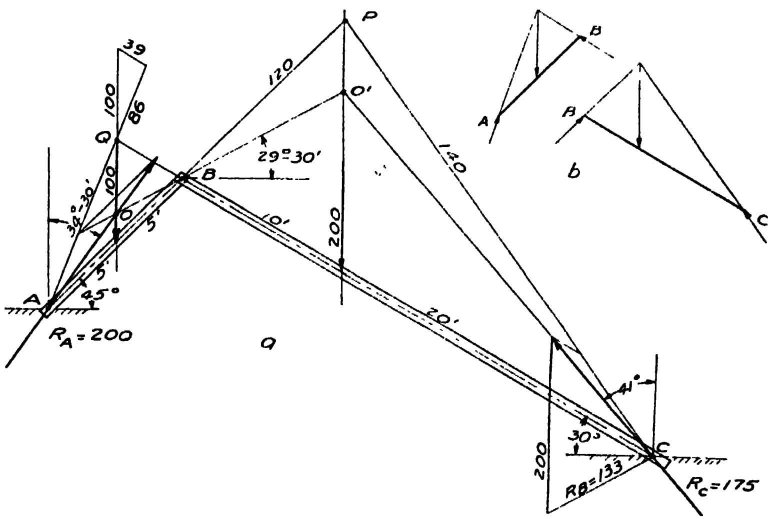


FIG. 4.

of the right leg. These two with the reaction at A are in equilibrium. All three forces are coplanar, concurrent, and act through point Q. The solution gives the value of reaction at A, 86 pounds and that at B, 39 pounds. Taking the right leg we see that 200 pounds, reactions at C and B are in equilibrium, and act through point P. The solution for this leg will give the reaction at C, 140 pounds, and that at B, 120 pounds. But the total reactions at A, B, and C are due to 100 and 200 pounds acting at the same time. Therefore, the reaction at A is equal to the algebraic sum of 86 and 120 pounds, or it is equal to 200 pounds. The reaction at C is equal to $140 \mathbin{+\!\!\!\rightarrow} 39 = 175$ pounds. The line of action of reaction of 200 pounds will intersect 100 pounds line at O, and the line of

reaction of 175 pounds will intersect 200 pounds line at O'. Connecting O with O' the line will go through pin B, giving the direction of reaction at B. Since the magnitude of the latter must be such that it should be in equilibrium with either 100 and R_A, or 200 and R_C, one of the combination will give the value of the reaction at B equal to 133 pounds.

It will be noted, while by analytic method we obtain the horizontal and vertical components of each reaction, by graphic method the actual reactions are obtained directly, which can be then re-

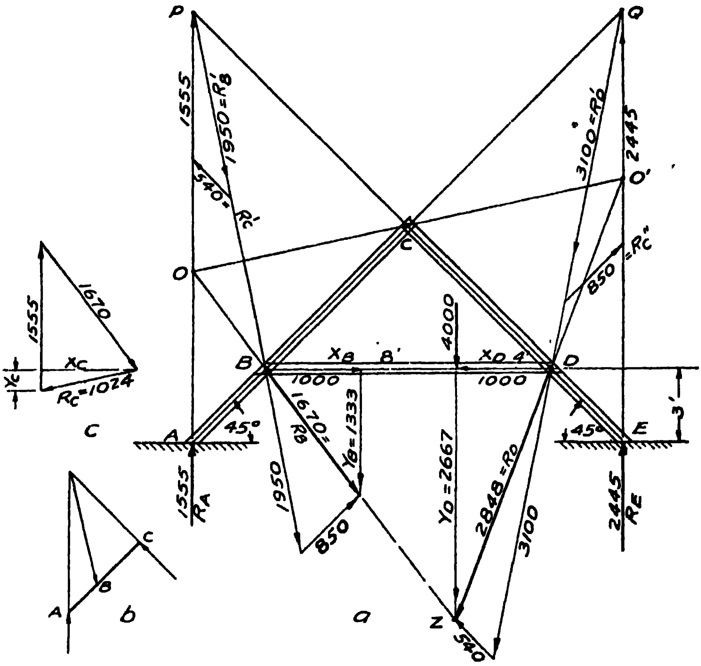


FIG. 5.

solved into their components if so desired. Note also that direct solution will give the angular direction of each reaction, whereas analytically another solution will be necessary to find the angles.

The results in comparison with those obtained analytically may differ slightly, but for practical purposes they can be considered satisfactory.

Figure 5 illustrates a three member frame. This is taken from the Applied Mechanics, A. P. Poorman. Legs AC and CE are on smooth surfaces at A and E respectively. By inverse axic method R_A and R_E reactions are equal to 1555 and 2445 pounds respectively.

Horizontal components at A and E, i.e. $X_A = X_E = O$. Therefore, $X_B = X_C = X_D$. Taking leg AC as shown in Fig. 5a and b, R_A is in equilibrium with the joint reactions at B and C. R_C' is in the direction of the leg CE. These forces meet at point P. The force polygon at P will give $R_C' = 540$ pounds, and $R_B' = 1950$. Taking leg CE and by similar process we find $R_C'' = 850$, and $R_D' = 3100$ pounds. But the actual reactions at B and D are equal to the algebraic sum of reactions, or $R_B = 1950 \mathbin{+\!\!\!\rightarrow} 850 = 1670$ pounds, and $R_D = 3100 \mathbin{+\!\!\!\rightarrow} 540 = 2848$ pounds. Figure 5c shows how R_C is obtained. For all the reactions, R_B, R_D, R_C it will be found that the horizontal components are equal, i.e. $X_B = X_C = X_D = 1000$ pounds. The solution indicates also that the forces at the joints, B, C, and D are in equilibrium with the given force of 4000 pounds.

From the above problems it is interesting to see that one does not have to visualize or attempt by other means of reasoning to determine the directions of the required forces, since each diagram is made according to definite rules, hence the process of following the direction of the lines, will easily show the character of each force.

While in classroom space may not permit to obtain very accurate results, in industry, however, one may find sufficient means and conveniences in laying out the diagrams to larger scale, and obtain better results. Universal drafting machines, better protractors, etc., will be found to be very valuable tools in this work. Errors can easily be detected, because in some cases it will be impossible to go any further, until the errors are corrected.

FALLING BAR PROBLEM

By R. T. LIDDICOAT

Assistant Professor of Engineering Mechanics, University of Michigan

The first students of engineering took their dynamics from teachers of mathematics. With the formation of the large engineering colleges, these men trained as engineers with only the required mathematics, then taught the dynamics courses. In a great many cases they listened to the chorus from the profession to the effect that engineers do not need much mathematics. The present teachers in charge of dynamics in the large schools are from these first classes and from later generations of students.

The results can be seen from our textbooks on dynamics. They are with few exceptions very elementary. One of the last books on the market in making a revision deleted viscous damping in the new edition. I presume it was because the subject was too difficult for the rank and file. In order that the subject remain simple and easily mastered, the problems are carefully picked to protect the student from reality. Graduates from these classes then teach other students. Such a procedure is not conducive to progress.

Constructively, I believe that our notion that the teacher can be recruited from the ranks of our graduates needs modification. Before becoming a satisfactory teacher of dynamics, for instance, a man should be given light teaching loads and he should be asked to master a program of study that would fit him at least to read the works of the great analysts—LaGrange, Coriolis, Stokes, Kelvin, and others. I went smugly on my way until a great Russian teacher came to our school and his lectures showed me the breadth of the subject.

"A prismatical bar of length l and weight w rests on a smooth frictionless table top, as shown in Fig. 1, and is held at B. If suddenly released, what angular velocity ω will it gain by the time it is free of the table?" (Statement of problem as given by Timoshenko and Young's original mimeographed "Dynamics.")

In Fig. 2

$$x_G \text{ (not shown)} = z \operatorname{Cos} \theta, \qquad \dot{x}_G = \dot{z} \operatorname{Cos} \theta - z\dot{\theta} \operatorname{Sin} \theta,$$
$$y_G = z \operatorname{Sin} \theta, \qquad \dot{y}_G = \dot{z} \operatorname{Sin} \theta + z\dot{\theta} \operatorname{Cos} \theta.$$

* Presented at the fiftieth annual meeting, S. P. E. E. (Mechanics), New York City, June 27–29, 1942.

Force in a given direction = the time rate of change of the momentum in that direction.

$$w \operatorname{Sin} \theta = \left[\frac{d}{dt}\left(\frac{w}{g}\dot{x}_G\right)\right]\operatorname{Cos}\theta$$

$$+\left[\frac{d}{dt}\left(\frac{w}{g}\dot{y}_G\right)\right]\operatorname{Sin}\theta = \frac{w}{g}\left[\frac{d}{dt}(\dot{z}\operatorname{Cos}\theta - z\dot{\theta}\operatorname{Sin}\theta)\right]\operatorname{Cos}\theta$$

$$+\frac{w}{g}\left[\frac{d}{dt}(\dot{z}\operatorname{Sin}\theta + z\dot{\theta}\operatorname{Cos}\theta)\right]\operatorname{Sin}\theta,$$

which reduces to

$$g \operatorname{Sin}\theta - \ddot{z} + (\dot{\theta})^2 z = 0. \tag{1}$$

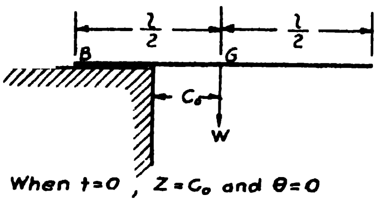


FIG. 1.

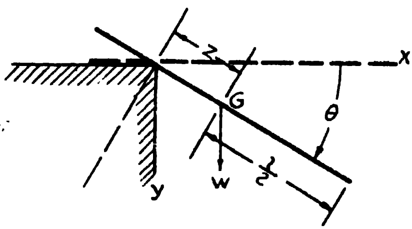


FIG. 2.

External Torque = Time rate of change of the Angular Momentum

$$wz\operatorname{Cos}\theta = \frac{d}{dt}\left\{\left(\frac{w}{g}\right)\left(\frac{l^2}{12}+z^2\right)\dot{\theta}\right\} = \frac{w}{g}\left(\frac{l^2}{12}+z^2\right)\ddot{\theta} + \frac{w}{g}2z\dot{z}\dot{\theta}.$$

Simplifying, we have

$$-gz\operatorname{Cos}\theta + \left(\frac{l^2}{12}+z^2\right)\ddot{\theta} + 2z\dot{z}\dot{\theta} = 0. \tag{2}$$

Equations (1) and (2) look quite formidable. Any change in choice of coördinates could not greatly improve them. The following method of solution was resorted to:

Set up two power series for z and θ in terms of time t

$$z = c_0 + c_1 t + c_2 t^2 + \cdot \tag{3}$$

$$\theta = k_0 + k_1 t + k_2 t^2 + \tag{4}$$

If the coefficients of t in (3) and (4) can be found, we will have a solution to the problem, valid for all values of t for which the series converge. This is true because $\ddot{\theta}$ will be zero at the instant the bar springs clear of the table since the table reaction on the bar and the external moment at this instant will be zero.

Preliminary Operations

c_0 in (3) is the distance z when $t = 0$, so c_0 is known. θ is 0 in (4) when $t = 0$, so $k_0 = 0$.

$\dot{z}$—the velocity along the bar is zero initially, so $c_1 = 0$ in (3).
$\dot{\theta}$—the angular velocity of the bar is initially zero, so $k_1 = 0$.
$\ddot{z}$—the acceleration along the z line is initially zero, so $c_2 = 0$.

In (3) and (4) attention is called to the fact that the subscripts of the c's and the k's are the same as the powers of t in the equations for z and θ. This is important in later discussion.

Before substituting the values of z and θ in (3) and (4) into (1) and (2) of auxiliary equations are necessary.

Auxiliary Equations

$$\dot{z} = c_1 + 2c_2t + 3c_3t^2 + \cdots (n+1)c_{n+1}t^n + \cdots, \tag{3a}$$

$$\ddot{z} = 2c_2 + 3\cdot 2c_3t + \cdots (n+2)(n+1)c_{n+2}t^n + \cdots, \tag{3b}$$

$$\dot{\theta} = k_1 + 2k_2t + 3k_3t^2 + \cdots (n+1)k_{n+1}t^n + \cdots, \tag{4a}$$

$$\ddot{\theta} = 2k_2 + 3\cdot 2k_3t + \cdots (n+2)(n+1)k_{n+2}t^n + \cdots. \tag{4b}$$

Note that differentiation with respect to t causes a shift in the subscript-exponent relationship. For the first derivative $c_{(n+1)}$ goes with exponent n. For the second derivative, $c_{(n+2)}$ goes with exponent n.

Expansion of Sin θ and Cos θ in terms of θ.

$$\operatorname{Sin}\theta = \theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} + \cdots. \qquad \operatorname{Cos}\theta = 1 - \frac{\theta^2}{2!} + \frac{\theta^4}{4!} - \frac{\theta^6}{6!} +$$

Determination of the Constants k_2, c_4, etc.

When values of (3) and (4) and their derivatives are substituted into (1), we get

$$\begin{aligned} g\Big[(k_2t^2 + k_3t^3 + \cdots) - \frac{(k_2t^2 + k_3t^3 + \cdots)}{3!} + \cdots \Big] \\ - [3\cdot 2c_3t + 4\cdot 3c_4t^2 + \cdots (n+2)(n+1)c_{n+2}t^n + \cdots] \\ + [(2k_2t + 3k_3t^2 + \cdots (n + \cdots 1)c_{(n+1)}t^n + \cdots)^2 \\ \times (c_0 + c_3t^3 + c_4t^4 + \cdots)] = 0. \end{aligned} \tag{5}$$

Substituting (3), (4) and derivatives into equation (2), we get

$$-g(c_0 + c_3t^3 + \cdots)\left[1 - \frac{(k_2t^2 + k_3t^3 + \cdots)^2}{2!} + \frac{(k_2t^2 + k_3t^3 + \cdots)^4}{4!} + \cdots\right] + \left[\left\{\frac{l^2}{12} + (c_0 + c_3t^3 + \cdots)^2\right\}\right]$$
$$\times (2k_2 + 3\cdot 2k_3t + \cdots (n+2)(n+1)k_{n+2}t^n + \cdots)$$
$$+ 2(c_0 + c_3t^3 + \cdots c_nt^n + \cdots)$$
$$\times (3c_3t^2 + 4c_4t^3 + \cdots (n+1)c_{n+1}t^n + \cdots)$$
$$\times (2k_2t + 3k_3t^2 + (n+1)k_{n+1}t^n + \cdots) = 0. \quad (6)$$

Equations (5) and (6) must hold for all values of time t. They will do this if they hold for the coefficient of each power of t. An equation is accordingly formed for the coefficients of each power of t as though it existed alone in (5) and (6).

The constant terms, or the coefficients of t^0, must add to zero in *both* (5) and (6).

There are no constant terms in (5).

In (6)

$$-gc_0 + \left(\frac{l^2}{12} + c_0^2\right)2k_2 = 0, \qquad \text{so} \qquad k_2 = \frac{gc_0}{\left(\frac{l^2}{12} + c_0^2\right)2!}.$$

The coefficients of t to the first power must add to zero so

$$(5) \text{ gives } 3\cdot 2c_3 = 0, \qquad \text{and} \qquad c_3 = 0.$$

$$(6) \text{ gives } \left(\frac{l^2}{12} + c_0^2\right)\cdot 3\cdot 2k_3 = 0, \qquad \text{so} \qquad k_3 = 0.$$

Equating the coefficients of t^2 in (5) and (6) to zero we get from (5) $c_4 = \dfrac{4k_2^2c_0 + gk_2}{4\cdot 3}$ and from (6) $k_4 = 0$.

The coefficients of t^3 in (5) and (6) give $c_5 = 0$ and $k_5 = 0$.

Equating the coefficients of t^4 to zero (5) gives $c_6 = 0$ and (6) gives

$$k_6 = \frac{gc_4 - \dfrac{gc_0k_2^2}{2!} - 20c_0c_4k_2}{6\cdot 5\left(\dfrac{l^2}{12} + c_0^2\right)}.$$ This process can be continued indefinitely.

General Observation

Equations (1) and (2) have a $\ddot{z}$ and $\ddot{\theta}$ respectively. When (3) and (4) are substituted into (1) and (2) giving (5) and (6), the term in t^n coming from the $\ddot{z}$ part of the Equation (1) will be $c_{n+2}\cdot(n+2)(n+1)t^n$. This is the only point at which c_{n+2} occurs in the equation of coefficients of t^n in (5). All of the other coefficients both c's and k's come earlier in the z and θ series than c_{n+2}. It follows that if c_0 to c_n and k_2 to k_n are known, then c_{n+2} can be found and by mathematical induction all of the c coefficients can be found.

In Equation (6) the term $k_{n+2}\cdot(n+2)(n+1)t^n$ will occur where $\ddot{\theta}$ appears in (2) and only there. All of the other coefficients of t^n will have c's and k's in (3) and (4) occurring earlier in the series than k_{n+2}. It follows by mathematical induction if k_2 to k_n and c_0 to c_n are known, k_{n+2} can be found.

Elimination of Odd Powers of t in (3) and (4)

Product of p Power Series

$$(a_0 + a_1t + a_2t^2 + \cdots)$$
$$\times(b_0 + b_1t + b_2t^2 + \cdots)$$
$$\times(d_0 + d_1t + d_2t^2 + \cdots).$$

$$\begin{aligned}\text{Product} &= a_0b_0\cdot d_0 + (\overset{\text{I}}{a_1b_0d_0} + \overset{\text{II}}{b_1a_0d_0} + \overset{\text{III}}{d_1a_0b_0})t \\ &\quad + (\text{all ways of combining } a, b \text{ and } d \text{ subscripts to add to } 2)t^2 \\ &\quad + (\text{all ways of combining } a, b \text{ and } d \text{ subscripts to add to } 3)t^3 + \cdots. \end{aligned} \tag{7}$$

The t^n of (5) has c_{n+2} as the new term sought and it occurs in $\ddot{z}$ alone. If n is odd (7) shows that each term such as I and II etc. in (7) contains one term with an odd subscript. It follows that if the c's and k's of odd subscript occurring in (3) and (4) earlier in the series than c_{n+2} are zero, c_{n+2} will be zero and terms of odd coefficient are ruled out.

The General Term of (3)

It is desirable to write out the general expression for the value of, say, c_{n+2} to facilitate passing on the detailed labor of finding the coefficients to a computing machine operator and to study the problem of convergence.

If the expansion for sin θ is cut to the first two terms, Sin $\theta = \theta - \frac{\theta^3}{3!}$ (which even at 60° will give .86 instead of .87), the general expression for c_{n+2} can be written out.

As explained, $\ddot{\theta} = 0$ at the required time when the bar leaves the table. So

$$\ddot{\theta} = 0 = 2k_2 + 6.5k_6t^4 + \cdots \qquad \text{and} \qquad t = \sqrt[4]{\frac{-2k_2}{6.5k_6}}$$

if the part of the series for $k_{10}t^{10}$ etc. is dropped.

A rough experimental check was made by slow-motion "movies" for a $\frac{1}{4}''$ diameter steel rod $12''$ long released with its c.g. $4''$ out from the edge of the table. The time found experimentally was within .01 second in .20 seconds. The problem was solved again in the same manner as that described except that a coefficient of friction of .3 was assumed. The time found by the two methods was on opposite sides of the value found experimentally.

Conclusion

Your attention has been recalled to the law,

Force in a given direction = the time rate of change of
the momentum in that direction,
(Referring to fixed directions)

and to the law

External Torque = the time rate of change of the Angular
Momentum.

In this case, Coriolis' law entered incidentally.

The power series has been called to your attention as a powerful tool in the solution of problems of this sort.

SANITARY ENGINEERING AS A PROFESSION *

By E. SHERMAN CHASE

Partner, Metcalf & Eddy, Engineers, Boston, Mass.

Sanitary engineering is that branch of engineering which relates to the betterment and control of environmental factors affecting the public health.

Origin of Sanitary Engineering.—The origins of sanitary engineering, like those of most human institutions, will be found in the distant past. As has been stated many times the Mosaic laws in part were concerned with sanitation and hygiene. Centuries ago the Chinese used alum for the clarification of water and the aqueducts and sewers of Rome are classic examples of ancient sanitary engineering.

In relatively modern times sanitary engineering problems arose in Europe with the general introduction of public water supplies and the water carriage system of sewers. Filters for the Thames River supplies were constructed as long ago as 1829. The sewers of Paris were made famous by Victor Hugo in "Les Miserables," written in 1862, and the stink of the Thames in the eighteen fifties led to governmental action in England to reduce the sewage pollution of English streams.

In this country the first public water supplies were introduced about the beginning of the past century, to be followed by sewerage and drainage systems.

Until the "germ theory" of disease demonstrated the bacterial origin of cholera and typhoid the objectives of sanitary engineering were public comfort and convenience. With the demonstration that certain infectious diseases are transmitted by food and water the emphasis was transferred to the public health aspects of sanitary engineering. This change of emphasis is reflected in the demand for changing the term "sanitary engineering" to "public health engineering." The important effect of the discoveries of Pasteur and his successors in bacteriology, biology, and biological chemistry, was the establishment of the relationship of these sciences to the art and practice of sanitary engineering.

As has been true in many specialized fields of engineering, the development of courses to give educational training in sanitary

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engineering followed the practical application of the newly acquired knowledge. Just about 50 years ago the first four-year course in sanitary engineering was set up at Columbia University, followed shortly by a second course at the Massachusetts Institute of Technology. Although few colleges or technical schools give separate courses in sanitary engineering today, there are a fair number which give sanitary engineering options with their civil engineering courses. This fact leads to a consideration of the fields of practice for which the technical schools should prepare their undergraduates.

Control of Environment.—Under the definition starting this paper environmental control and betterment lie within the province of the sanitary engineer. There are five broad classes into which sanitary engineering activities may be grouped:

First, the development and protection of public water supplies;

Second, the collection and disposal of the wastes resulting from man's activities;

Third, the control and eradication of rodent and insect pests, particularly those involved in the spread of disease;

Fourth, the sanitation of food production and distribution;

Fifth, general environmental cleanliness, including prevention of atmospheric pollution, street cleaning and miscellaneous controls over living, working and recreational conditions.

Branches of Sanitary Engineering Practice.—The practicing sanitary engineer usually finds himself in one or the other of two groups. The first group is that group which is directly interested in the administrative and governmental promotion of sound engineering principles, in the five broad fields of practice above outlined, which make for public health and the prevention of disease. The second group is that which is concerned with the physical incorporation of these principles into public or private works, their design, construction and operation.

Sanitary Engineering in the Field of Public Health.—In the field of public health the sanitary engineer is called upon to supervise the execution of health laws, exercise general oversight of sanitary works, and carry out sanitary engineering research. The agencies involved may be municipal, state or federal. These agencies employ many sanitary engineers whose duties relate to law enforcement and to the promotion of public sanitation projects.

Sanitary engineering divisions of state health departments are typical of the public services which call for engineers trained in the fields of practice previously outlined. Every or nearly every state in the Union has a state sanitary engineer. In some state health departments a substantial number of engineers are employed and in other states but one or two. Naturally the larger the state the

larger the engineering staff of the health department. In the case of the larger engineering staffs there is apt to be specialization of duties whereas in the small health departments, with one engineer, his duties are broad and cover a wide field of activity.

Probably the most important duty of the state sanitary engineer is the sanitary protection of public water supplies. This involves oversight of watersheds, prevention of pollution and the general supervision of operation of purification plants. Particularly important in this service is the promotion, by educational persuasion, of water supply betterments. Another phase of water supply protection is the control or elimination of cross-connections between public and private supplies.

Next in importance, at least as far as established custom is concerned, is the control of stream pollution by sewage and industrial wastes. This function of state sanitary engineers usually includes review of plans for sewerage and sewage treatment works, submitted by designing engineers and the examination of streams, subject to pollution. Routine inspection of sewage treatment plants and the maintenance of general supervision of their operation are other duties assumed by the engineers of state health departments.

In southern states mosquito control, for the prevention of malaria, is an important field of activity for health department engineers. This involves supervision of drainage projects, their construction and maintenance. Rodent control has not received much attention except from the sanitary engineers in coastal regions. These remarks apply to continental United States. In areas where rodents serve as intermediate hosts for the organisms causing plague and other parasitic diseases the engineer comes into action.

The state sanitary engineer plays an important role in the production of clean and safe milk and, in coastal areas, the protection of shell fish from pollution. Pasteurization of milk in particular frequently comes under the jurisdiction of sanitary engineering divisions.

In addition to the above outlined duties state sanitary engineers are frequently required to look into the sanitation of public swimming pools, the abatement of nuisances, the general sanitation of camps and to advise with respect to water supply and sewage disposal for state institutions. In one state, at least, the sanitation of beauty shops and barber shops comes under the state sanitary engineer.

The preceding brief discussion of the multitudinous duties of state sanitary engineers applies in a limited way to county and city sanitary engineers. In the case of city sanitary engineers they may

be required to oversee the cleaning of streets and the collection and disposal of rubbish and garbage.

The second broad function of sanitary engineers in the field of public health relates to their connection with research problems in sanitary science. In this activity they are likely to be associated with chemists and biologists. The first outstanding example of sanitary engineering research in the United States is that of the Lawrence Experiment Station of the Massachusetts State Board of Health, where research has now been carried on for over a period of fifty years. In Federal circles the work of the experiment station of the U. S. Public Health Service at Cincinnati is outstanding. Other important sanitary engineering research stations have been operated at one time or another by individual cities, in the interest of advancing the art of water purification and sewage treatment. In recent years certain equipment manufacturers have carried out important researches in the application of equipment or processes.

Public and Private Sanitary Engineering Works.—The sanitary engineer engaged in the public health field has to do with the application of sanitary principles in the administration of health laws. He seldom is called upon to incorporate these principles in actual structures. This is a matter for engineers in private practice or in charge of public works departments. The sanitary engineer engaged in the design of works must be competent to embody scientific principles in the basic design of sanitary works and in many cases execute the detail structural design. He must be familiar with the state of the art and must have sufficient experience and judgment to determine what methods to adopt and what to reject.

Many young sanitary engineers serve as inspectors on construction and in some cases such early employment leads to their remaining in the construction end of the profession, either as construction superintendents or as contractors. In any event the engineering office, public or private, having to do with the actual construction of sanitary works, usually expects to carry on technical supervision of such construction.

With the completion of projects involving the purification of water, the treatment of sewage and industrial wastes, it is frequently the function of the sanitary engineer to assume charge of their operation. This is a field in which at present there is a demand for technically trained sanitary engineers in excess of the supply, particularly at military establishments. In some ways this is a particularly interesting and instructive line of activity, for the young sanitary engineer. It has always seemed to the speaker that construction and operation experience should be had by the sanitary engineer before he attempts to design.

In the past twenty-five or thirty years there has developed a new field of activity for the sanitary engineer and that is in the promotion and sales departments of manufacturers who produce equipment or materials used in sanitary engineering projects. This sort of work requires individuals with suitable temperaments and personalities. The danger to young men entering this field is their exposure to the temptation to sacrifice intellectual and professional integrity for the sake of meeting sales quotas. However, engineers with the proper training in sanitary engineering and of unimpeachible integrity can serve a most useful purpose.

No reference has been made to the somewhat limited field of education. Here, of course, a few graduates in sanitary engineering find their life work, and as sanitary engineering subjects are taught in connection with civil engineering courses in a number of colleges and universities, there are opportunities in this field from time to time.

Essentials of Sanitary Engineering Education.—A practicing sanitary engineer cannot resist an opportunity to express to a group of engineering educators his views on sanitary engineering education. Any product is judged by how it functions, and this is true of the product of our institutions of learning. Experts always seem to be disagreeing among themselves, particularly educators, but when a rank outsider attempts a suggestion in the educational field they forget their disagreements and gang up on him. However, it should not be forgotten that it is the layman who is the customer for the goods turned out by the universities and technical schools and that he is in a better position to appraise those goods in service than the professor who had only their processing.

It seems to the speaker that in undergraduate courses in sanitary engineering there should not be too much specialization or too deep excursions into allied but different fields of specialized knowledge.

Obviously the sanitary engineer must be thoroughly grounded in the fundamental principles of the natural sciences, physics, chemistry, geology and biology. The arrangement of courses in these subjects, however, should be in accordance with the problems which will arise in the practice of sanitary engineering. There is always the danger that the enthusiastic teacher of physics, for example, will try to make physicists out of all his students.

Another "must" in the education of the sanitary engineer, as is true with all types of engineer, is mathematics. Again the relation of the mathematical courses to the practice of engineering needs to be stressed.

When it comes to technical subjects it may be somewhat difficult

to select those which are basically important. The work of the sanitary engineer involves so many phases of engineering and science that there is a tendency to overload the curriculum. Certainly mechanics, structural design, materials of construction, hydraulics, design of water works and sewage works, principles of public health and sanitation and elements of electrical and mechanical engineering should be among the subjects taught.

The speaker is a believer in the need for the development of some degree of manual skill in all engineering students. The young engineer's first job usually depends upon his ability to perform some service with his hands. Consequently he should be able to survey accurately, to draw reasonably well, and to perform laboratory technique. There is a tendency to decry these relatively humble skills, but it must be remembered that most engineers have to start at the bottom and that the better they perform the simple tasks the sooner is promotion and advancement likely.

In addition to technical knowledge the sanitary engineer needs to have a reasonably broad cultural background, and to this end subjects such as history and literature should be included in his education. Particularly important is training in the proper and accurate use of the English language, for writing and speaking. Language for the engineer must be another precision tool for the transmission of his thoughts to others. Some degree of training in the principles of economics and in business and public health law should also be given.

Advanced work in specialized phases of sanitary engineering and the expenditure of any considerable amount of time on research problems should be saved for post-graduate work. There are too many fundamentals involved in the training of sanitary engineers to warrant side trips into interesting but non-essential activities.

The Future of Sanitary Engineering.—No one can say what the future holds for any type of engineer. There will continue to be the same problems in the United States as have existed for years, and new fields of activity will undoubtedly develop. Furthermore, it seems not improbable that American-trained sanitary engineers will be called upon to play an important part in the post-war world in the now not-so-far reaches of the globe. Sanitation problems of vast magnitude exist in Africa and Asia, awaiting attack by competent sanitary engineers. It behooves those entrusted with the education of sanitary engineers to envision those problems and to prepare their students for service in spreading the gospel of sanitation to all the nations.

DISCUSSION

By RALPH W. HORNE

Partner, Fay, Spoffard & Thorndike, Boston, Mass.

Mr. Chase has presented a very interesting and comprehensive paper in which he has set forth the history, scope and diversity of sanitary engineering work.

The speaker was interested to note the definition given for sanitary engineering. No doubt, most of us have at one time or other attempted to put down on paper his conception of the definition of the profession in which he is engaged. The speaker therefore submits the following definition:

> Sanitary engineering, as a profession, is the practice of the art of organizing and directing man's efforts and of utilizing the forces and materials of nature for the protection and improvement of the public health.

Practically the same meaning is conveyed by both definitions.

The speaker agrees heartily with Mr. Chase in his statement regarding the world-wide fields which will be open to postwar activities of the sanitary engineering profession. It is important that we should organize and prepare to meet a greatly increased demand for modern sanitation after the war is terminated.

It appears that in Mr. Chase's reference to the "Essentials of Sanitary Engineering Education," there is implied an invitation for the consumer to tell the producer what he thinks of his product, and I therefore am taking this opportunity to point out certain apparent "shortcomings" of the average technical school graduate.

My remarks are based on my knowledge of the workings of the engineering organization of which I am a partner, and are applicable particularly to the type of engineering work handled by that concern. However, I believe the remarks are applicable to numerous other private engineering offices. The engineering work usually handled by private engineering concerns includes investigations and reports, engineering designs, preparation of plans, specifications and other contract documents, and engineering supervision of construction. Clients of many private engineering concerns are largely either municipal, state, or federal agencies and, perhaps to a lesser extent, private concerns.

Engineering employees of private engineering concerns generally fall within one of four groupings, depending upon the relative responsibility of their work. These four groupings, arranged with

the less important responsibilities in group (1) and the highest responsibilities in group (4) are:

(1) Draftsmen, survey men and computers
(2) Designers and detailers
(3) Assistant engineers
(4) Engineers

An evaluation of the work of technical graduates employed by our firm under the several groupings indicates the desirability for certain additional qualifications to make the men more useful to us.

It is taken for granted that the technical graduate will have received adequate basic training in mathematics and the fundamental sciences.

It is my opinion that the average inexperienced technical graduate is lacking in drafting ability and needs a better appreciation of the value of well-made plans, and the value of a clear graphical presentation of facts by use of plans, charts and diagrams. Good drafting ability will be helpful to an inexperienced technical graduate in retaining steady employment and in gaining practical knowledge, through drafting work, of construction details worked out by his more experienced superiors. The technical graduate should have been taught that drafting is not too menial a task for him to perform.

Furthermore, an employee's value would be enhanced if he were trained to recognize when he had reached a satisfactory solution of a problem and taught to understand the need for economy in the engineering expense put into the solution of a problem. Some instruction regarding the business side of the operations of an engineering organization should provide a worthwhile addition to the usual "stock in trade" which the technical graduate has to offer his employer. The technical employee should be able to judge as to the reasonable amount of time needed to solve a problem, or perform a task.

The technical training should give a man sufficient instruction in report writing to enable him to recognize the facts to be set forth and their relative importance, and should train him to present facts clearly and in logical arrangement, so that the client will be convinced that the solution presented is a correct one. The ability to put thoughts clearly on paper so that they will be readily understood is also valuable in the preparation of contract documents and specifications.

The training of a man for any branch of public works engineering should give him a good understanding of ordinary political practices in so far as they may affect the operations of municipal, state and

federal agencies; and the man should understand that he can become better posted regarding such matters by actually serving, as an elective representative of the people, in his own municipal or state government. Service in an elective capacity in municipal or state government is often looked upon as desirable training for a lawyer; it is an equally desirable training for an engineer whose work is to deal largely with public works undertakings. A clear understanding of the manner in which the operations of a public works department may be affected by political influence will frequently be of much value in arriving at the practical engineering solution of a public works problem.

In summarizing, I would point out that both employers of engineers and engineering employees will find it to their mutual advantage, if the institutions for engineering education will turn out men, as sanitary and civil engineers, who are better qualified as draftsmen, and more appreciative of the value of good draftsmanship; men trained to recognize when a satisfactory solution of a problem has been accomplished; men better trained to present clearly and logically in written report the solution of a problem; and men informed with regard to the effect of political influence upon the viewpoint of those who are entrusted with the operation of municipal, state and federal agencies.

By EDWARD WRIGHT

Sanitary Engineer, Massachusetts Department of Public Health

The sanitary engineering profession is at present in a very difficult position because of the fact that a great many sanitary engineers have been inducted either into the Sanitary or Engineer Corps of the Army or into similar branches of the Navy and Marine Corps or have entered the U. S. Public Health Service and, while all sanitary engineers regret the drafting of qualified sanitary engineers into the Infantry or Artillery or direct Naval services when their services to the Army or Navy in their professional capacity would be of value, the situation is of course such that it is inadvisable to attempt to request further deferments except for the essential key men. To show the difficulty in keeping the staff intact it may be pointed out that an engineer in a lower bracket recently with the department is now a welder in a shipyard at over double his salary as a state employee. Another engineer in a higher bracket has recently been called to South America to a virgin field for a sanitary engineer. Fortunately, he is doing very valuable water supply and sewerage work in a country where such improvements are unknown.

This leaves the profession in a difficult position to carry on the necessary sanitary engineering work required to keep the home fires burning and to carry on such work as is required particularly by state departments of public health and the U. S. Public Health Service in connection with the sanitation of Army and Naval establishments and the effect of these establishments on the public. It is such a difficult situation that Mr. Chase obviously was unable to find time to write his paper in time to enable the speaker to prepare a suitable discussion. Many of the key men in the Sanitary Engineering Division of the Massachusetts Department of Public Health have been called into the service. The remaining young or very mature men are required to work overtime in carrying out an increasing number of sanitary engineering problems. In fact the dearth of sanitary engineers is not dissimilar to the present lack of medical and nursing personnel. Recently an important manufacturer has been unable to obtain the services of a properly qualified sanitary engineer to assist him in his waste disposal problem.

The priority situation has made the procurement of materials for water supply and sewerage construction difficult and has had a decided effect in slowing normal construction of water supply and sewerage works. Without this condition the scarcity of suitably trained sanitary engineers would have been more serious.

It is to be assumed that the speaker's discussion should relate to sanitary engineering in public health departments. The Massachusetts Department of Public Health has a Sanitary Engineering Division which, under normal conditions, is staffed by some 51 engineers, 24 chemists and bacteriologists and 32 in the clerical force, or a total of over 100. The staff now consists of 21 engineers, 17 chemists and bacteriologists, 24 clerks and 2 non-professionals. It has been necessary to give up much of the regular work ordinarily demanded by the public or to get others to do it. The Division comprises not only strictly sanitary engineering work but a laboratory in the State House for water and sewage analyses including microscopical examinations, and also an Experiment Station at Lawrence where the bacteriological work and research activities are carried on.

It can safely be said that there is no professional service other possibly than medicine which is closer to the public than that of sanitary engineering nor are the other professions more worthwhile and essential to the welfare of the public. This has generally been recognized by all classes of citizens including those holding elective offices who generally assume a "hands off" attitude. The sanitary engineering profession has numerous names. In some instances, it is called public health engineering. The most recent is to class the work as environmental sanitation. The basic work, of course,

relates to water supply and sewerage of which there are numerous phases. A list of the other subjects involving the sanitary engineer in public service arranged alphabetically is as follows:

Air Pollution and Conditioning	Malaria
Bathing Places	Milk
Camps	Mosquitoes
Cemeteries	Nuisances
Cosmetics	Pigs
Crematories	Police Stations
Cross Connections	Ratproofing
Flies	Shellfish
Foods	Smoke
Garbage	Stream Pollution
Hydraulics	Teaching
Housing	Ventilation
Industrial Hygiene	Vermin

In the old days sanitary engineering was a small branch of civil engineering. It is now a distinct branch of the engineering profession with an enlarging field including a great deal of chemistry, biology, microscopy, mechanical engineering and the study of statistics. The requirements in mechanical engineering are increasing materially particularly in connection with sewage disposal where now complicated mechanical devices are required particularly in the handling of sludge and in its incineration.

The sanitary engineer is required to meet the public rather more than many other branches of the engineering profession because of the public nature of the work. In addition, the sanitary engineer must know the law and certain consulting sanitary engineers are involved very frequently in litigation regarding public matters. The sanitary engineer must know various industries particularly in relation to waste disposal from such as leather establishments, gas works, wool handling establishments, powder mills, paper mills, wire mills and distilleries. The sanitary engineer in a health department must be conversant with the general laws of the state and the special acts under which municipalities operate. He must be prepared to introduce new legislation and to assist in its passage and must expect to devote a very considerable amount of time in teaching elected officials the necessity of suitable public health laws.

The sanitary engineering profession is one in which the professional sanitary engineer may receive a minimum compensation but he will realize a maximum amount of satisfaction in the work. There are two members of the staff of the Engineering Division of

long standing who do not hold college degrees and the first Chief Engineer of the Department of Public Health, who was subsequently President of the American Society of Civil Engineers, held no college degree but practically every member of the present staff had a degree from a recognized college course in sanitary engineering before his appointment. While the Division and other sanitary engineering organizations are now searching for sanitary engineers, it is not likely that any can now be found who are suitably qualified as the field is reduced to an absolute minimum.

The work of the engineering profession when well carried out will give the individual a great satisfaction of doing a necessary and worthwhile job. One hesitates to think what the State of Massachusetts would be like had it not been for the sanitary engineering profession.

AERONAUTICAL ENGINEERING COURSES FOR UNDERGRADUATE AND GRADUATE CURRICULA *

By HANS REISSNER

Illinois Institute of Technology

The preparation of aeronautical engineers presents special problems and a great responsibility for the schools of higher technical education in this time of emergency and for a field which has become of paramount importance.

The Army, the Navy, the Civil Service and the aeronautical industry, as it has been emphasised by several leading executives, needs two classes of young engineers. They must have a comparatively small number of men highly educated as well in the basic sciences as in all applications necessary for new design and experimental and theoretical research, and they need also a much larger number of young engineers able to do the routine work such as tests of materials and structures, performance calculations, stress analysis, detailing designs with understanding and reliability.

It is perhaps too simple to say that for the second class the undergraduate study should be sufficient and for the first class the postgraduate study required. In fact for the graduates of the first engineering degree a postgraduate education for the just named routine work is indispensable but generally given in their service or factory and graduates of higher engineering degrees will, after a time, see their efficiency in fields other than original research and other than the development of new technical ideas.

Another choice must be made by the schools themselves for the system of their courses and by the factories in the selection of employees.

There is one system of preparation demanding a general engineering education either as mechanical or as civil or even as electrical engineer as a prerequisite and giving the special aeronautical education by optional courses. These would be subjects treated partly relying on more general knowledge acquired in the courses of machine design, steam and gas engines, engineering

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mechanics, structural analysis and so on, applied to the special aeronautical courses.

If with this system a separate aeronautical department is in existence it has to coöperate with the other departments in a number of common courses and to emphasize the unity of engineering science and stresses the adaptability and versatility of the engineer for different fields in seeing connections between the different fields which a specialist perhaps may overlook.

On the other hand there is the system of an entirely independent aeronautical department specializing in courses like engineering mechanics, physics, chemistry, strength of materials, statics, dynamics and hydro- and aerodynamics, structural analysis and engine design just for the application in aeronautical engineering. This method has of course the advantage that some time is saved in the proper aeronautical courses of aerodynamics and stress analysis and design of airplanes and that the graduates are so specially prepared as not to need as much additional apprenticeship as employees of an aeronautical plant.

I think both systems can do good work and besides very much depends on the personality of the individual student.

In both systems of education special features appear in the treatment of the fundamental subjects of aero- and hydrodynamics, stress analysis and design of which some may be mentioned here.

In aerodynamics of the airplane besides the practical performance and stability calculations such subjects as the concepts of circulation, of vortex bundles and vortex sheets (free and fixed and their conservation), of induced velocity fields, of free and self-excited vibrations are to be emphasized much more than in other compressibility effects below and above the velocity of sound and changing working conditions of the engine with altitude and precompression engineering fields.

In the stress analysis the multiplicity of loading conditions following the great number of possible states of flight, atmospheric conditions and wind irregularities and of maneuvers is an important chapter in itself, very involved if compared with loading conditions in buildings, bridges or engines.

The necessity to go to extremes in light weight requires special considerations in the choice of high quality materials and the allowable stresses and deflections with different safety factors at different places in the airplane.

In the stress analysis proper, there are the special chapters on bending of continuous beams under compression, on the tension field theory of thin webs and airfoil skins, on the shear lag in stressed skin construction, on the bending, torsion and buckling of the shells, appearing particularly in the fuselage, on the impact

stresses and the spring and frictional action in undercarriages. All these subjects appear rarely in other fields of engineering.

The course in airplane design presents peculiar difficulties in the great variety of types, and controls, in the numerous accessories and instruments and in the unavoidable fact that many design features remain either unknown or unexplained being either factory or military secrets.

The instructor will bring the airplane types into a certain order as much as possible according to their service, that is classify them as sports or private, passenger, freight and military types. He will have to show the often conflicting demands—on *c.g.* location, visibility, aspect ratio, maneuverability, weight and drag saving, speed range, propeller and undercarriage. The reasons for high wing and low wing structures, for sweep back, dihedral and twisting of wings, the means to avoid flutter and stalling must also be thoroughly discussed.

The final purpose of this course which is to prepare the student for the design complete in general features and showing at least some of the more important details in ribs, spars, hinges and control surfaces, undercarriage and propeller, can only be attained by giving him enough sample structures in models and drawings of existing and approved structures.

Teaching experience seems to show that very much teaching material must be put at the disposal of the instructor and the student and very much time must be spent and high credit be given to induce the student to finish a project.

The schools will have to decide how much they want to treat in undergraduate and how much in graduate courses and how much they will leave to the later apprentice work in the factory after having taught the fundamentals of theory and of general and detail design. These reservations, and general considerations in mind, it may be allowable to make the following statements: The undergraduate training should lead the student so far as to be a good draftsman, stress-analyst, testing man and aerodynamicist with only a certain amount of instruction left over to his chief for the ordinary propositions of the factory or office, where he has to work later on.

The post graduate training should not make the student too conceited to be willing to do the drafting, testing or stress work just enumerated but it should make him capable if the opportunity arises of working out new technical design ideas, to suggest more efficient or time saving procedures, and to find by appropriate systematic research the cause and the elimination of failures.

One more general statement not new but valid and essential for all kinds of teaching may be repeated here.

The courses should not be given with the ambition of covering the subject completely but rather with the intention to accustom and familiarise the students with the fundamental methods and their thorough application so intimately as to make them able to help themselves when new problems arise and to look up the pertinent references and to apply the methods learned in school for new problems.

In fact the student should not be overwhelmed with too many facts and special methods. It is better to give him the confidence that he has enough basic background to tackle a problem even if it has not been treated in the course.

Therefore if no attempt is made in this paper to give a detailed disposition of the curricula for aeronautical engineering it must be understood that each instructor must make his decision according to the number of hours allotted and to his preference and opinion about the value in fundamental typicalness of the different chapters. Besides it may be of advantage to change the disposition of a course especially for postgraduate study from term to term not only good for the students but also for the freshness of mind of the lecturer.

Then there is the question of textbooks. A textbook of course may have the ambition of being not only a help for the student and the instructor during the course but also a reference and help for his later practical work and so only a certain fraction of the textbook need be covered in a course. Yet I must criticise a number of textbooks in that they do not use the opportunity of their ample printing space to give the possibility to study the derivation of theorems in the theory of potential or vortex flow, or of buckling of plates or shells or of flutter and so on either in footnotes or in an annex.

From the title of this paper it may have been expected to hear detailed statements and figures about the number of hours of each term and course about the chapters in each course to be treated, about the division into undergraduate and postgraduate courses and about the prerequisites of admission to the courses and about the textbooks to be recommended.

Of course much thought must be given to these questions, but it would lead too far to go into all the varying conditions of the schools and the varying aims of their education.

It may be allowed to refrain from detailed programs and to state only the following conclusions:

Four special aeronautical courses are necessary at least.

1. Aerodynamics of Aircraft
   Stress analysis of Aircraft

Design of Aircraft
Theory and Design of Aircraft Engines.
These courses should require at least 4 week hours for sixteen weeks and extra drafting hours for the last two named.

2. The undergraduate courses must give the practical formulae needed for the routine work in aircraft industry but in such a way that the students get an intimate knowledge of the derivation of these formulae.

   The graduate courses must familiarize students with the advanced problems of the aircraft science relying on their advanced mathematical and technical knowledge and show them in which direction research problems are ripe and useful.

3. The prerequisites for the undergraduate courses should be good credits in advanced calculus, in first elements of total and partial differential equations, in physics, chemistry, strength of materials, elements of statics and dynamics, in structural analysis and in drafting of machine elements.

   The last two subjects may need special provision for students of mechanical and of civil engineering respectively and a close coöperation with the departments giving these preparatory courses especially necessary in mathematics.

4. There is in all schools in the United States and abroad a sharp division between the aeronautical courses proper and the course on aeronautical engines. In fact civil engineering students while they are well prepared for the aeronautical branch of engineering are not prepared for engine design, and even mechanical engineering students would first have to specialise in automotive engineering and affiliated subjects of thermodynamics, metallurgy and chemistry.

   The education in aeronautical engine design from the theoretical and the designing as well as from the laboratory point of view is extremely important and should not be left too much to the aftergraduate teaching in engine factories. Yet experience has shown that it is better to keep it apart as a special branch of aeronautical education.

5. The schools and their instructors must regularly exchange ideas and experience with the different places of development and manufacture and also try to check the results, successes, and mistakes of their alumni at the points where they appear later.

RECRUITING ENGINEERS *

By R. L. SACKETT

Chairman, Committee on Selection

War requires that we do the unusual. The traditional must sometimes be modified or abandoned. Thus the engineering colleges have undertaken forms of training and education commonly remote from their main objectives. These constitute new burdens and for some of them, faculties must be expanded or extra hours are required of teachers without additional income.

There is also the temptation in war time to abandon real objectives temporarily perhaps and to lower standards to a point where undergraduates are not prepared to carry out the duties imposed on them and graduates are unable to perform the tasks which employers expect them to carry. The line dividing the warrantable compromise from one which is a delusion is often difficult to draw precisely. In general, engineering colleges have insisted on maintaining standards of quality.

There are those who believe that any high school graduate should be admitted to engineering college instruction if he stands a chance of learning something about drafting, mathematics, physics and military drill. The applicant who is deficient in scholastic ability in mathematics, science and drawing may leave at the end of one or two years. Has he obtained the best preparation which his capacity fits him for? Since some 60 per cent to 75 per cent fail to graduate it seems reasonable to conclude that many of those who do not graduate lack qualities which can be discovered by modern evaluations of high school records and test scores.

By careful guidance it is possible to advise a boy or girl toward educational and occupational objectives for which they are adapted by taste, scholastic evidence and interview. There are manipulative and operative skills in the field of production as well as those of a more analytical type such as design. All fields of interest and experience should be explored in order that the proper type of schooling or training may be presented for consideration. If this method were more generally followed, preparation for war or peace work might be expedited because shorter courses than two years or four years in college are adequate for many lines of endeavor.

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Waste time and lost effort will be reduced by more careful selection of those admitted to engineering schools. The expense to society and to the individual will both be reduced if placement in college is made more effective. The trade school and the technical institute must bear their proportional part of the burden in preparing students to take that place in industry where they can serve best and from which they stand the best chance of rising to positions for which they are best fitted.

The question of whether an engineering curriculum provides the best preparation for war or for peace does not enter yet. In the majority of cases, the requirement for admission is a high school diploma. Where the diploma is supplemented by a rating of the high school, by requiring scholastic achievement above the minimum or by tests, the results in general show a higher percentage of graduates.

In only relatively few institutions are the economic and social interests of the student given an appraisal. His future depends on interests, abilities and personality which receive little consideration in the process of admission.

It is difficult to estimate the value which accrues to one who attempts to adjust himself to a career for which he is not fitted. Much more of value to the individual results from application to a course of study or a job in which there is interest, aptitude and ambition. A feeling of fitness and that there are future opportunities constitute incentives which may make the difference between failure where one feels at a loss and success where one feels that they have found themselves, however vague those feelings may be.

Under war conditions there should be flexibility of curricula so that the student may adjust himself to conditions not otherwise easy for him to master. A degree of elasticity in curricula and of adaptability by the student might solve certain problem cases which now lead to withdrawal or failure. There are many such students who will serve well after a more or less extended engineering education and they are needed at present.

What value does a sense of economic well-being have? Those who feel that they are equipped to be engineers have a degree of economic security that compares favorably with other professions. Wages and opportunities attract applicants. Poor risks are as sensitive to good prospects as are those best fitted for engineering.

Tests of Eligibility for College

There are dependable tests of scholastic preparation designed to show fitness, or lack of it, to pursue a college or university course

of undergraduate study. These are tests of essential knowledge and attitude acquired at home, in high school, by reading and elementary experience.

The results of such scholastic Aptitude Tests have been correlated with college grades received afterwards and the results are valuable.

There are also tests of various skills and aptitudes which yield reliable results. They are being employed by industry, in determining the best job for an applicant.

Institutions which have made a study of the high and preparatory schools from which they draw students have found it mutually valuable. It will improve the prediction of success if secondary schools are rated according to the percentage of their students of given scholastic average grade who graduate from college. The variation in the quality of preparation makes such a rating plan desirable if justice is done those who are better prepared.

Tests may be required of those whose average grade in high school is low. Those not prepared to pursue a college career should be refused admission as a matter of simple justice to those who are better prepared.

An institution can improve its admission practice by counseling those students who seem to be lacking in preparation or personality. No formula for admission is entirely adequate because conditions vary from one institution to another and from one high school to another. The individuality of the applicant should also be recognized. An interview by an understanding teacher with an applicant of doubtful fitness can serve to inform the applicant, change his purpose or assure him that he has the desired inventory of abilities. Some can be warned of the problems which they face because they appear to lack qualities which are considered necessary. Human contact furnishes an incentive to those of certain temperaments.

In a pamphlet entitled "Engineers are Needed" which has been published by the U. S. Office of Education and has the approval of the War Production Board, there are suggested steps in giving sound occupational advice to those who are considering engineering as a career. There are references to guidance material, a number of different types of tests are described and their use is suggested. At the end is a personality record, a skeleton interest test and a very complete copy of the student's high school record. These are aids to counseling the student concerning participation in an engineering education. It is evidence that the high schools should be advised to counsel concerning the fitness of students for various fields of usefulness.

Predictions

An institution which weighs all the information in its possession concerning an applicant may discover how effective its selection is by making a prediction of relative success or failure of those admitted. Such a procedure helps the admission office to discover factors not previously uncovered.

Those few institutions which have made such predictions have improved the percentage of those graduating. Numerous factors have probably contributed to the improvement. Whatever the causes may be, it is a contribution to the war effort to select those who will stand the best chance of equipping themselves for effective service. Those who will not succeed ought not to be encouraged to study engineering or any other field requiring a capital investment in their education unless there is a fair prospect of return.

We have depended too much on Providence to provide Divine Guidance, which we have failed to supply.

Differential Tests

During the past fall a battery of tests was given to about 2000 entering students of arts and engineering. The purpose was to give further study to the problem of selection. Do students at that time in their growth show differences in ambition, aptitude and preparation which can be evaluated? Can qualities be measured which show an inclination toward arts or toward science and engineering? If there is a differentiation of talents which is justfied by subsequent achievement, there is a valuable aid to counseling. Dr. Bartlett will describe the study which he has made with the cooperation of engineering and arts institutions and also of high schools in New Jersey. This study was made possible by President A. R. Cullimore of Newark College of Engineering who loaned us Dr. Bartlett to conduct this investigation. The results are distinctly promising.

GUIDANCE AND PLACEMENT OF ENGINEERING STUDENTS *

By RUSSELL S. BARTLETT

Headmaster, The Gunnery School, Washington, Conn.†

As a boy approaches graduation from high school, there are two questions for which he must find the answer:

1. For what area of study and employment am I best fitted?
2. At what level of study will I derive the greatest profit?

Both of these questions have been neglected by the colleges. Often the answer is sought to another question, but in a passive rather than in a positive sense: "Is this applicant fit to enter our institution?" Either we permit him to enter the institution or we tell him he cannot enter, usually without offering any useful suggestion as to what he should do. If an applicant is admitted he may be attempting to make of himself a mediocre engineer out of a brilliant prospect for some other area of study. On the other hand, there may be boys entering arts colleges, who will be moderately successful there but would be brilliant engineers. Better, certainly, is some measure of positive guidance which, considering the boy, the job, and the demand, will each give a push in the right direction. Certainly we can do a better job in guidance when we know more about the boy. It may then be necessary to say to him: "You lack the highest qualifications for the field of technology; probably in other times you would be well advised to study journalism or business administration; to-day, with the great demand for men with technical training, your best opportunity and greatest service lie that way." Clearly our responsibility reaches beyond the mere acceptance or rejection of the applicant.

After the boy is properly guided into the field of technology, there is the question of level. Has he the needed equipment to succeed in professional engineering? Should he attempt a sub-professional career, starting through a technical institute? Are his qualifications such that he will achieve the greatest success through training in a trade school? These questions are related; yet the means of seeking the answers are quite distinct.

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† Study made at Newark College of Engineering.

Finding the Area of Most Effective Study

Though our ultimate aim is to discover the area of most effective employment for each individual, because of the difficulty of finding suitable criteria of effective employment it is probably best at the start to attempt to discover the curriculum in which the boy will achieve the greatest success. There is the added advantage that the time lapse is not so great, particularly if we start by using success in the freshman year as our criterion. One must recognize that freshman grades may not be highly indicative of later success. Against that weakness must be balanced the weakness of unreliability of grades after the students have started specialization. We cannot be sure that a certain Grade Point Average in Chemical Engineering is equivalent to the same average in some other curriculum. In some cases we are very sure that they do not indicate the same academic success, because the competition is keener in one group than in another. Furthermore, there is reason to believe that the requirements for success are different in different fields of engineering. Later, it may be possible to establish separate criteria and make independent studies for different branches of engineering, though the numbers would be small except for our largest institutions. Thus, for any reliable conclusions it would be necessary to include a number of classes, extending the time required and introducing an error due to progressive changes in methods and standards. To begin with, then, we seek methods of predicting success in the freshman year, and of predicting that field in which the greatest success may be achieved.

When the idea of a test of scholastic aptitude was first accepted, there was little or no attempt at differentiation. There was one general aptitude, measured largely in terms of command of the English language. Later investigation soon showed that this general aptitude was a composite of many parts, and that different persons possessed these competent aptitudes in varying degrees. Thurstone has succeeded in isolating a number of such components, possibly as many as ten or a dozen. His researches, however, concerned themselves solely with testing materials and the intercorrelations obtained with an experimental test group. From these studies arose the Thurstone Test of Primary Mental Abilities. Studies are continuing with this test, but at present it does not seem to be the most promising for our purposes, in that little attempt has been made so far to relate these primary aptitudes to areas of further study and employment. Once we have accepted the principles of individual differences, we look around for means of evaluating the mental equipment of each

student, seeking to discover his regions of strength and of weakness. Scrutiny of his scholastic performance in high school, with special attention to contrasting achievement in different subjects, is a natural first step, but one which proves relatively unfruitful. Of course, if a student has shown consistently superior work in mathematics he should continue in a field in which it is employed. More common is an erratic record in that a boy may do better work in mathematics in one year, better work in English or history during another. The boy or girl is growing, and is subject to change. Further, motivation may vary from year to year and from subject to subject. Add to this confusion the fact that schools differ widely in emphasis on different studies and in standards maintained, and one is forced to the conclusion that comparative performance in different fields in school is at best a crude indicator of comparative performance in college.

Use of standard tests of achievement certainly adds definiteness to the picture rendered by academic performance. Yet even if this record were perfect in reliability, it would still fail to give a complete picture. Too many areas of study are not touched at all in school or are dealt with so lightly that a grade is not a fair index of ability. Furthermore, academic success and performance on achievement tests is dependent upon the quality of the teaching. A set of records will tell what a variety of students have done, under a variety of conditions; this may be but little related to what they will do when working under identical conditions for all.

Certainly there is need for a measure of academic aptitude in many areas of study. By academic aptitude we mean the readiness to profit from further study; this is undoubtedly related to success in past study, but is not coextensive with it. Tests of academic or scholastic aptitude, general or specific, help to show whether a student has that quality of mind which is necessary for academic success, either in general or in specialized areas.

THE YALE BATTERY OF TESTS OF DIFFERENTIAL ACADEMIC APTITUDE

Starting over ten years ago, Dr. Albert Beecher Crawford, of the Department of Personnel Study of Yale University, has developed a series of tests of academic aptitude in different areas of study and employment. Many others have contributed to the development of the battery. After mention of the work of the Carnegie Corporation and the College Entrance Examination Board, the indebtedness to others may best be expressed in a recognition of the happy situation that exists among most makers

of tests whereby materials are freely loaned, provided only that acknowledgment is made. Thus, though the Yale experiment has been of limited duration and scope, experiences of many others in restricted areas of testing have made their contribution to the development of this Yale Battery. Tests of Scholastic Aptitude or Verbal Comprehension, of Artificial Language, and of Space Perception or Visualization have long been accepted as standard and reliable indices of aptitude. Springing from a trial with a few tests, a full battery came into being in 1936, consisting of six tests, whose titles, together with their nearest modern counterparts, are shown below:

1936 Title	*1941 Title and Number*	
Verbal Comprehension	Verbal Comprehension	I
Artificial Language	Artificial Language	II
Scientific Aptitude	Verbal Reasoning	III
Scientific Originality	Quantitative Reasoning	IV
	Mathematical Aptitude	V
Spatial Relations	Spatial Visualizing	VI
Mechanical Aptitude	Mechanical Aptitude	VII

Analysis of results for the tests as a whole and for individual items have brought about a gradual refinement, with the elimination of unsatisfactory sections or items. Each test has consisted of a number of parts, and there has been some shifting of these parts. One section of Test IV (Quantitative Reasoning) formerly was in Test V (Mathematical Aptitude). The tests were first used with test groups of students at Yale, and with whole classes (10th, 11th, and 12th grades) at a number of secondary schools, mostly private and mostly in the East. Lately the tests have been given to all entering freshmen at Yale. A few of the tests have had slightly different forms for the school and college populations. From a scrutiny of results this test battery appeared to offer greatest promise of assistance in the solution of our problems. Accordingly a trial of the tests in a wider field was planned. With the advice of Dr. Crawford, six tests of the battery were selected as likely to afford good differentiation between aptitudes for several areas of study. Test III was omitted, since it offered little differentiation, though an excellent test of general academic aptitude. A number of institutions were invited to participate in a testing program. Because of the desirability of securing test results from non-engineering as well as engineering students, invitations were extended only to institutions including both types. Tests were given to almost two thousand freshmen, during October and November, at the University of Florida, the University of Missouri, Northwestern University, Pasadena Junior College, the University of Ten-

nessee, and the University of Texas. These institutions administered a battery of five * or six tests to their incoming freshmen, and returned the materials to us for scoring, reporting, and

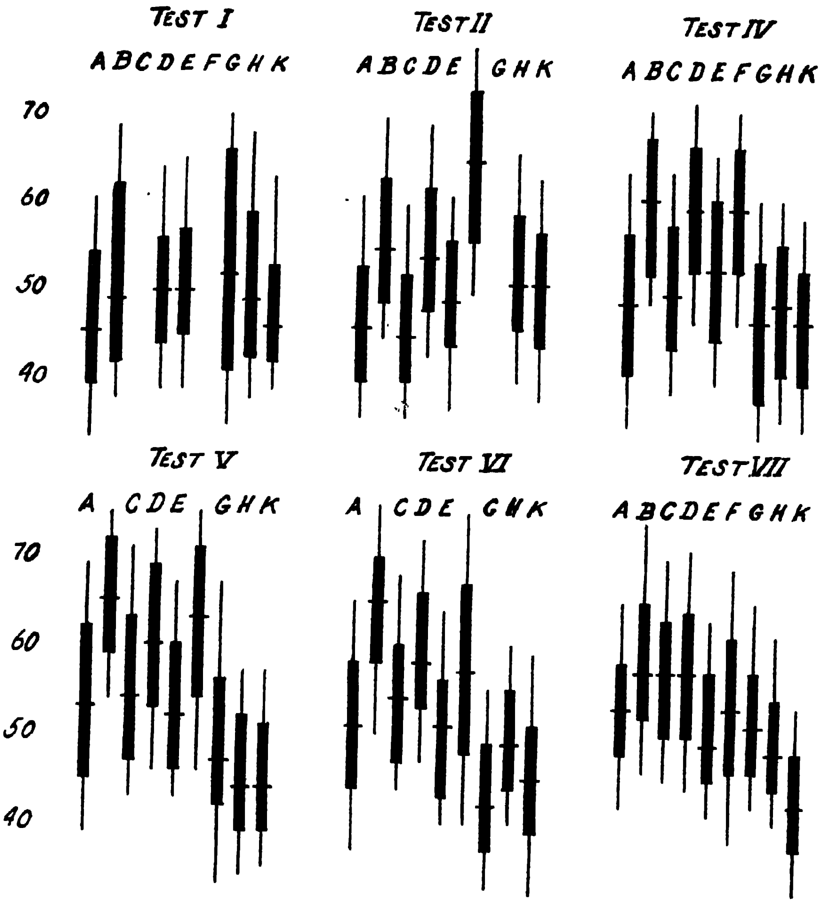


FIG. 1. Distributions of scores of various groups of students, Yale Differential Aptitude Tests. *A, B, C, D, E, G,* are groups of engineering students. *F* is a mixed group, strongly liberal arts and science. *H* and *K* are non-engineering students, to be paired with *C* and *E*. Each bar shows scale score for percentiles 90, 75, 50, 25, 10, in its group.

analysis. Since the tests had already been given in September to all Yale freshmen, we have available for study a varied and sizable test group. In Fig. 1 are shown the distribution of scores of these

* At some institutions a standard test of verbal aptitude already a part of the testing program, was substituted for Test I of the Yale Battery.

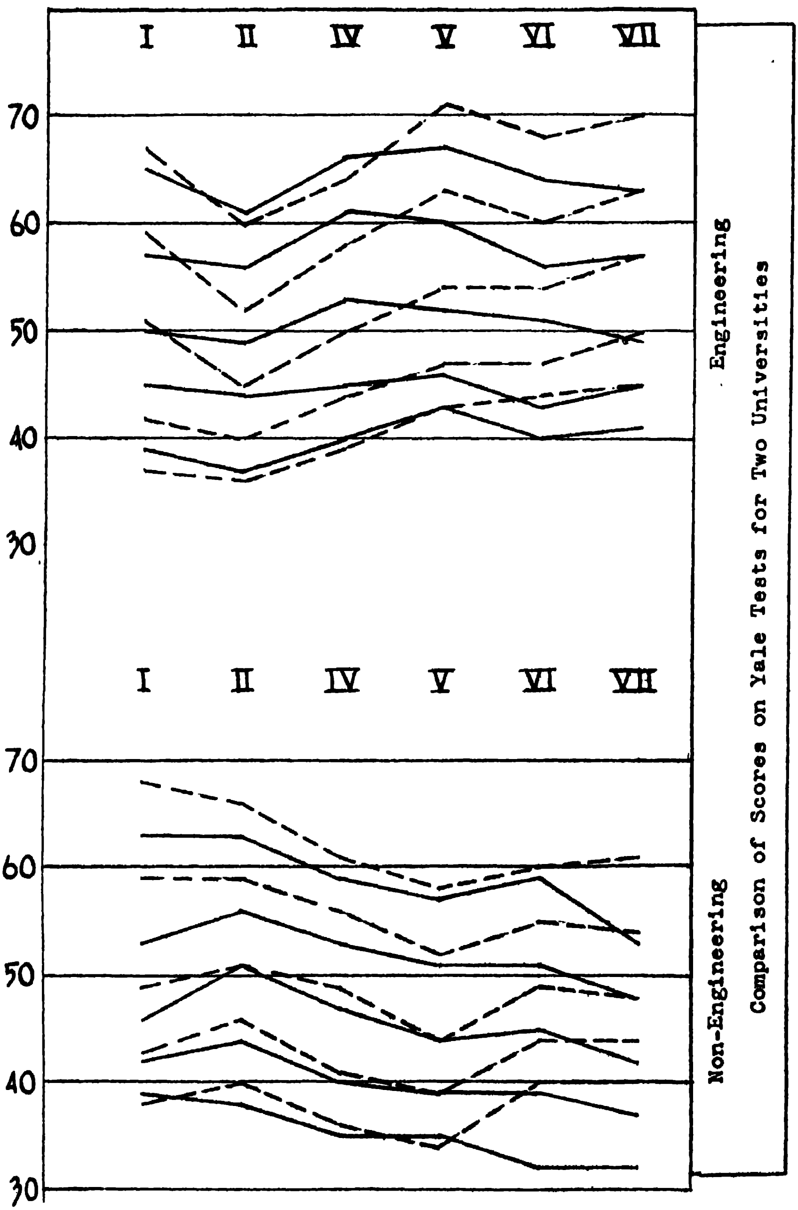

I
II
IV
V
VI
VII
70
60
50
40
30
Engineering
I
II
IV
V
VI
VII
70
60
50
40
30
Non-Engineering
Comparison of Scores on Yale Tests for Two Universities

FIG. 2

institutions on this test battery. Fig. 2 * shows in contrast, the scores achieved by comparable groups of engineering and non-engineering students, showing, first, the general characteristics of the two types, and secondly, variations on these general characteristics due to local conditions. Clearly engineering students are superior in those qualities measured by the higher numbered tests, non-engineering students inferior in these areas. The lines drawn solid for one institution dashed for the other, indicate scores achieved at percentiles 90, 75, 50, 25, 10, for the several tests.

Subsequently a group of high schools in and around Newark, New Jersey, was invited to administer the tests to bona fide college aspirants among their students, preferably in the eleventh grade. Participating were about 1,000 students in the Barringer, Central, East Side, South Side, and Weequahic high schools in Newark, together with Columbia High School in South Orange-Maplewood, and the high schools in East Orange, Montclair, Plainfield and Summit, and Newark Academy, a private secondary school. Distribution of scores achieved by these groups are shown in Figure 3. The tests are the same as those in the college testing program, with one exception, a test in mathematical aptitude, which depended too much upon current studies to permit the same test to be used in both groups. Evidence that the tests are measures of aptitude is found in the comparable range of scores of the two groups, college and school, in most cases two years apart in academic age. In one test the school boys and girls achieved better results than the college students. For each group a scaled score was established on each test, with a mean value of 50 and a standard deviation of 10, thus making possible a direct comparison of scores for several tests with widely varying maxima or averages in raw scores. The scales were established independently for the college and for the school groups. Thus, comparisons cannot be made between the figures and diagrams presented for the two groups, where these are in terms of scaled scores. For the school group, in addition to the variations in different areas, the results for school H are interesting, since this is a technical high school.

Results of Past Trials of the Yale Test Battery

Follow up studies have been made of the subsequent academic careers of boys who took this test battery some years ago. No very

* In Fig. 2 the solid lines indicate scores on the several tests, at the 90th, 75th, 50th, 25th, and 10th percentiles, above for engineering freshmen, below for non-engineering, at a certain university. The dashed lines present similar information for another university. Thus it is possible to study general differences between engineering and non-engineering students, as well as the local characteristics of either group.

high correlations were found with later grades in particular courses, though some highly significant differences were noted. Thus, for a certain group one test was found to correlate about 0.60 with

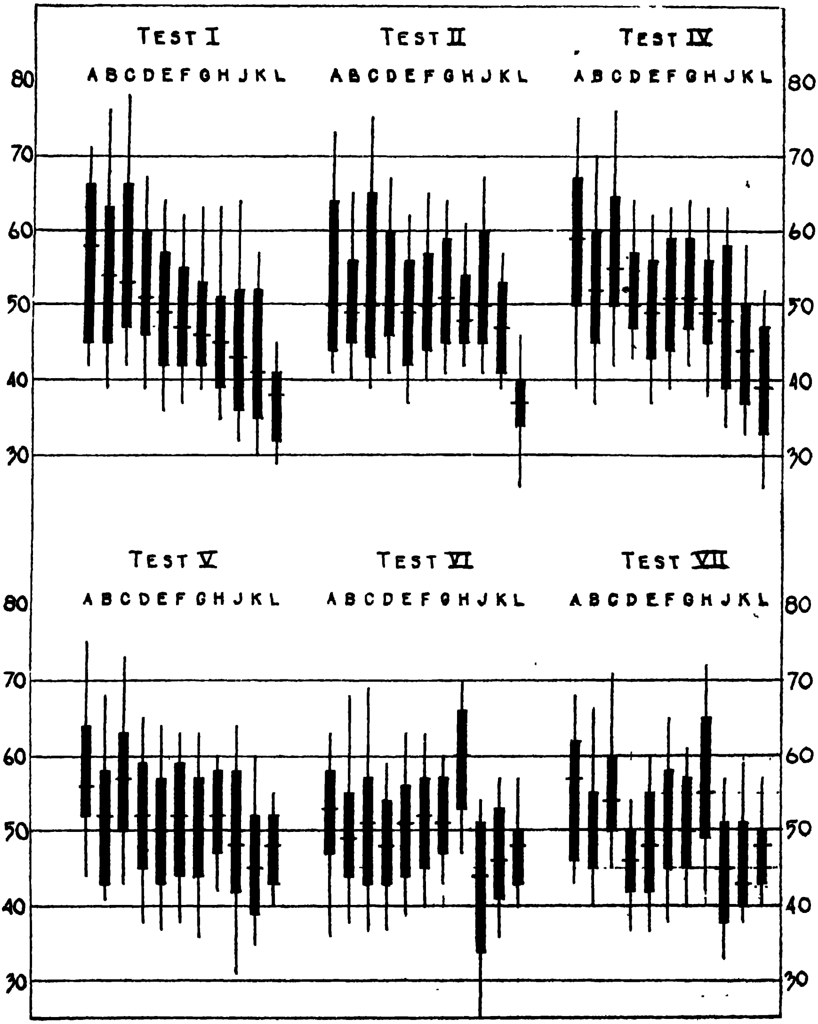


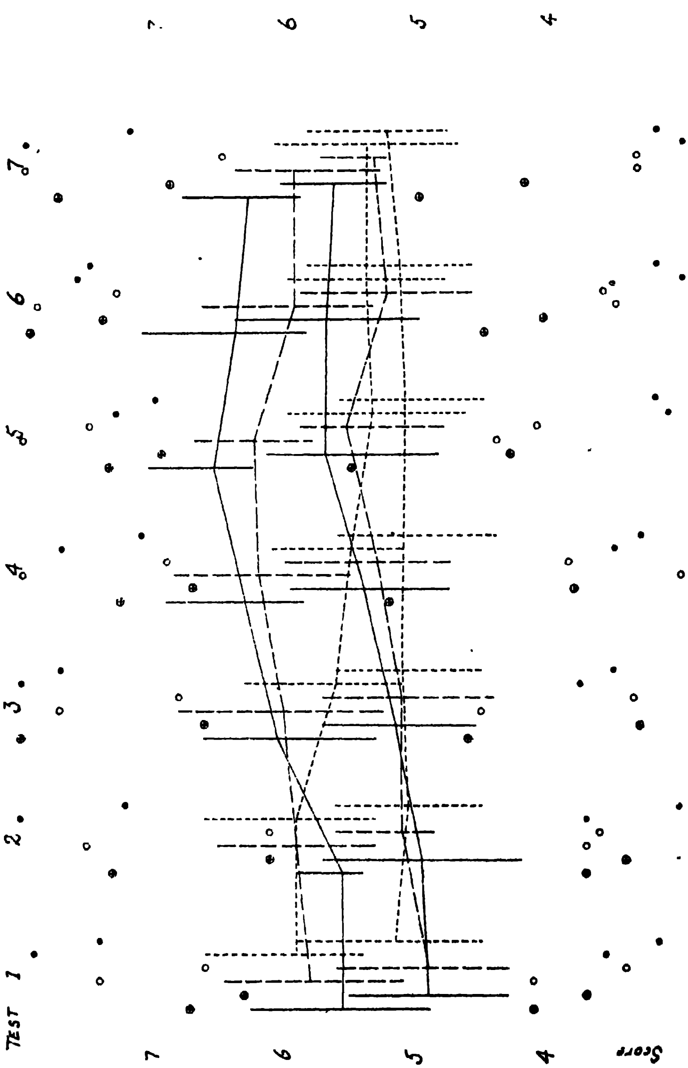
FIG. 3. Distribution of scores for high schools, Yale Differential Aptitude Tests. Each bar shows scale score percentiles 90, 75, 50, 25, 10, in one school.

a related subject, less than 0.20 with grades in an unrelated subject. Considerable difficulty was experienced at first in establishlishing the validity, whether good or bad, apparently because of

differing standards in the participating schools. Recently it has been possible to follow up, to a limited extent, the performance in college of boys taking the tests in school. Difficulty was experienced here, however, because of the small group in any one course at any one college. Furthermore, a process of self-selection led to an extremely limited range of test scores for correlation with grades in certain courses. For example, in freshman mathematics very few are found with test scores below 50 in related tests.

The question naturally rises, "If a test score obtained at matriculation in college is indicative of later success, will the test scores have similar significance, when obtained two years earlier at the eleventh grade level?" Or, "Will results which are good predictors of success at the twelfth grade also indicate the nature of success in college?" A complete answer to these questions is not possible at present. Certainly boys change and grow. External conditions and motivations are bound to have a marked effect. Yet there remains some positive evidence of the persistence of differential aptitudes. A group of boys took the test of verbal comprehension in two successive years. The correlations obtained, about 0.825, is considerably better than the correlation between grades in successive years of study of English. A lower correlation was found, 0.675, between successive attempts at the spatial relations test, but this was shown to be due, in part at least, to the study of plane geometry in the intervening year by some of the students. Studies are now in progress, relating test performance in school to performance in later years in school and college, which will answer, partially, the questions above.

Correlations between individual test scores and performance in particular subjects, or in all subjects, fail to give a complete picture. The pattern of performance on all tests carries a clearer message. Reference has already been made to Fig. 2, which shows characteristic patterns of engineering and non-engineering groups. This depends for its value upon the soundness of the students' choice of a curriculum. It will be at least a year or two before we can tell how wisely that choice was made. Fortunately, Dr. Crawford has made available figures which bear on this point. He has examined the scores obtained on the Yale Tests at the time of matriculation, of students who later achieved distinct success during three years of study. Contrasted with these scores are those obtained by the group whose achievement was the lowest. In Fig. 4 are plotted the test scores of the top and bottom quarters in the Yale School of Engineering, the Sheffield Scientific School, and Yale College (of Liberal Arts). The bottom quarter includes those who have failed and dropped out up to this point, with enough of



SCORES ON YALE APTITUDE TESTS
Achieved at Matriculation by Groups Determined by Success (Top Quarter) or Failure (Bottom Quarter) in Three Years of Subsequent Study in the Fields of: Each Vertical Line Shows, for its Group (Top or Bottom Quarter in Designated School) the

FIG. 4

the lowest grades still remaining to make up one quarter of the total enrollment.

Though certain facts are self-evident from the figures, a few points deserve special comment. The test in Verbal Comprehension, Number I, is highly discriminating for all groups, and, curiously enough, Test II, Artificial Language, is almost equally valid in distinguishing good from poor students regardless of their curricula. It is highly significant that the lowest quarter students in Yale College do almost as well as the top quarter on the higher numbered tests. Evidently ability in mathematics and a spatial and mechanical sense is of little importance in this liberal arts college, and it may be further deduced that the tests offer fair measures of those attributes. All seven tests are discriminating for engineers, though it is evidently possible for students to succeed in engineering studies with only moderate facility in English. Apparently aptitudes measured by the higher numbered tests are slightly more important. Very probably, a more detailed study is required to show what happens to students in engineering who are significantly low in certain traits.

Placement with the Field of Technology

The problem of guiding the boy into the most suitable branch of engineering, civil, mechanical, etc., is almost exclusively a local problem, conditioned by the requirements and opportunities peculiar to each institution and to each locality. It is impossible to deal with that problem in a general discussion. It may not be amiss, however, to urge upon each engineering school a study of its own methods of guidance and an attempt at evaluating their success. In particular, there would be a real gain if the admissions or placement officer would risk making a prediction with regard to each candidate, and studying the results, particularly those cases where the prediction proved wrong.

Let us suppose that a boy has been tested. His high school record has been evaluated. It is concluded that he should enter the field of technology. At what level, or better, at what type of institution should he apply for admission? Prognostic tests of aptitude, such as those discussed, offer real aid in answering these questions. A boy with superior mechanical ability and spatial sense, but weak in mathematics, should seek his further education in a trade school or technical institute. One who is weak in academic subjects in high school, but has excelled in shop courses and commercial-mechanical subjects should follow the same advice. Doubtless the college registrar is prepared to give such advice to boys who are rejected, and will even suggest to others that though

he is ready to give them a trial if they insist they would probably be better served elsewhere. Still, the chief concern of the admissions officer is the simpler question of acceptance or rejection. At the

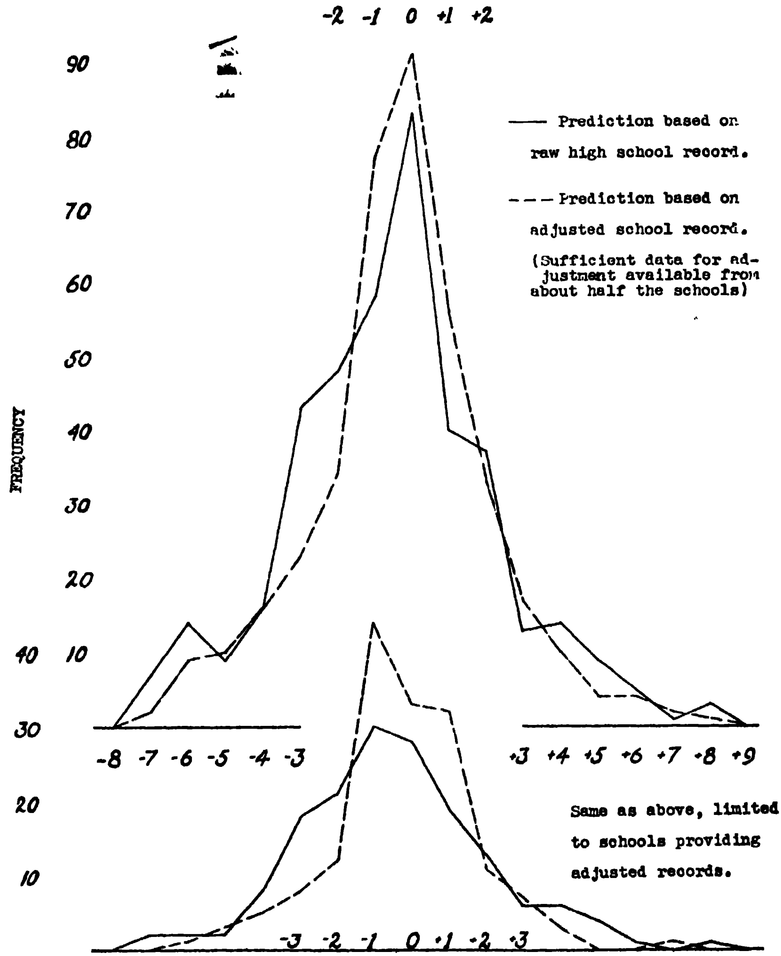


FIG. 5. Difference between prediction and performance.

present state of guidance and measurement techniques, that question should receive a major part of our attention.

Records have been made available at the Newark College of Engineering. From preliminary studies of last year, a data card was prepared and sent to four engineering schools, for the assembly of data bearing on the admission of the student and his

subsequent academic success. The results were late in coming in, so that complete studies have not been possible. Yet certain conclusions can be drawn. First, it must be emphasized again that local conditions are important. For a college drawing boys from a small number of schools, particularly if the schools themselves

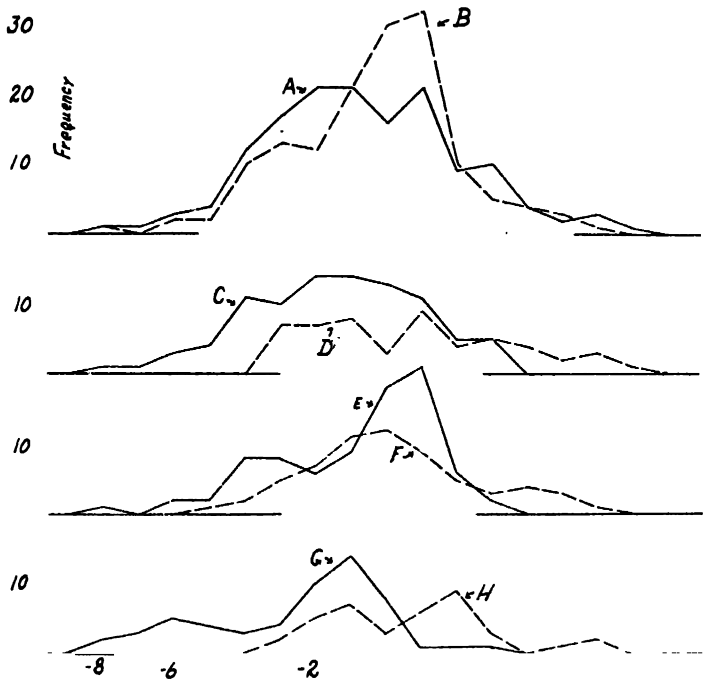


FIG. 6. Prediction-performance for freshman year, 1940–1941, in deciles of the class. Prediction based on record in high school, adjusted for performance of students in previous years.

A, not adjusted;	B, adjusted; for all schools providing data sufficient for adjustment.
C, D, not adjusted;	C, prediction in top half.
	D, prediction in bottom half.
E, F, adjusted;	E, prediction in top half.
	F, prediction in bottom half.
G, H, no adjustment possible;	G, prediction in top half.
	H, prediction in bottom half.

are rated on past performance, the high school record is one of the best indices of college success. Where boys come from many schools, of differing standards, more reliance must be placed on test results. Invariably a combination of test results and school records is better than either one alone.

Studies were made of records for a college drawing from a limited number of schools. In figure 5 will be found plotted the difference between prediction and performance (prediction based on high school records), when all schools are treated alike, and when corrections are applied, based on the performance of boys

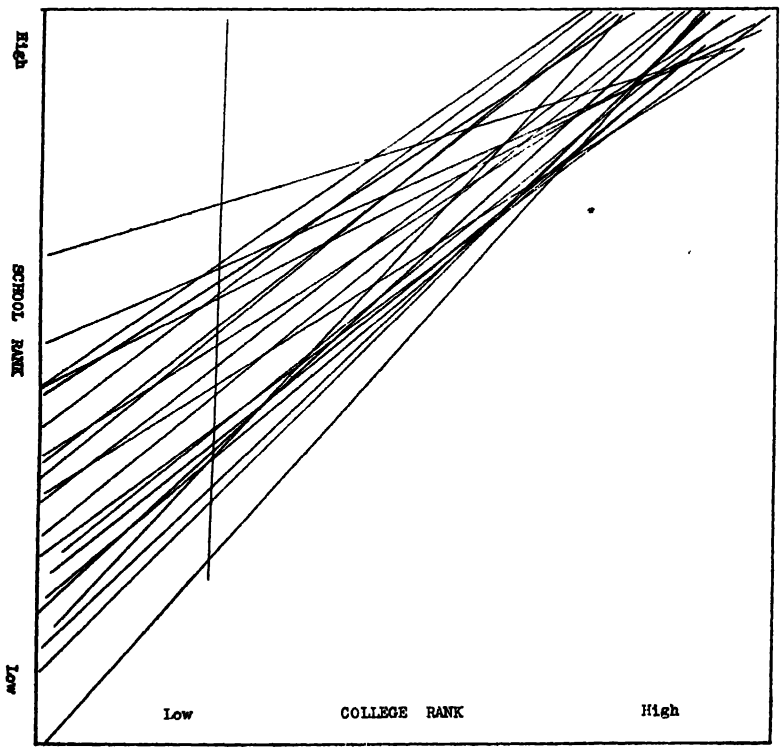


FIG. 7. Rating of high schools.

from each school having a substantial number. Since records were available for a two-year period only, many schools did not supply enough students to justify a correction.* Figure 6 shows the results when the correction factors from the past two years are carried forward and applied to give a prediction for the class completing its freshman year last June. The prediction is not

* In Figure 7, each line indicates, for one school, the expected relation between school rank and college rank. Though most of the lines converge toward the top, as might be expected, for one school it appeared, strangely, that a boy might be expected to rank in the eighth decile from the top, in college, regardless of his performance in school.

quite so satisfactory, nor is the improvement so marked, from the correction. The trouble lies to a considerable extent in a marked shift in population, more boys coming from schools which were rated on meager evidence or which were not rated for lack of evidence. There is every indication that a substantial improvement in reliability of prediction is obtained when these corrections are applied. Also, the practice of making the prediction puts the predictor on his mettle.

Another interesting point arose in this attempted prediction. A number of boys were admitted for whom failure could be predicted as a virtual certainty. (Of 26 placed by prediction in the

TABLE I

CORRELATIONS OF ENTRANCE CRITERIA WITH COLLEGE PERFORMANCE

		A		*B*		*B′*					*C*	
		41	42	41	42	41	42	43	44	45	41	42
H. S. Rank	12	.46	.48	.39	.45	(.61	.54	.62	.29	.37)*		
ACE Psych.	22	.35	.25	.44	.41	.46	.55	.41	.36	.17	.53	.46
L-Score	23	.28	.22								.42	.40
Q-Score	24	.30	.16								.47	.41
English Ex.	27	.47	.35	.48	.44	.34	.46	.42	.40	.40	.53	.43
Math Exam.	29			.69	.64	.48	.65	.54	.29	.30	.54	.43
Chem Exam.	33			.57	.56	.58	.59	.55	.55	.54	.53	.30
Local Exam.	35	.35	.30								.57	.44
	36										.50	.43
	37										.51	.50
	38										.32	.30
Fr. 1 Sem.	41				.85		.80	.55	.60	.65		.88
2 Sem.	42							.51	.56	.63		
Soph.	43								.69	.80		
Junior	44									.84		

* The group of figures in parentheses are highly unreliable, perhaps should not be included.

lowest fifth of the class, 20 achieved that distinction during freshman year.) Inquiry showed that many of these boys were admitted, despite low scholastic record, because of evidence of good citizenship or other desirable personal qualities, probably as a result of an interview. Here is a difficult problem. Granting the importance of considerations of personality in the making of an engineer, there is an obvious miscarriage if a boy is admitted to engineering school because of those qualities, and flunked out because of academic shortcomings that were apparent from the beginning.

Unfortunately this school is one which administers tests at admission to doubtful candidates only. As a result it is almost im-

possible to evaluate the usefulness of the tests as predictors, since the population taking them is small and of highly restricted range.

An interesting contrast is afforded by the correlations presented in Table I. Various admissions and entrance criteria are listed at the side, and the correlations are given with first and second semester averages for the freshman year, for two institutions, *B*, an endowed university drawing students from an extensive region; *A*, a state college with a more limited range, and the inevitable concomitant, more uniformity in high school standards.

College performance is measured in terms of grade point average or equivalent measure of success in all studies: 41, First Semester, Freshman Year; 42, Second Semester, Freshman Year; 43, Sophomore Year; 44, Junior Year; 45, Senior Year.

A, B, C, class of 1944 in engineering at three institutions. *B'*, class of 1941 at same college as *B*.

The contrast is quite striking. For *A* the high school rank is the best predicator of academic success during the freshman year, though no prediction is good. The use of one or more of the test results, in a multiple regression equation or in an estimated weighted average, would certainly lead to improved prediction, though it would never be very good. Unfortunately in both of these cases records have not been obtained for several consecutive years, so that the rating of the schools is not possible. Curiously, the results for B indicate that almost any test is better than the high school rank. This is not too surprising, when one considers that the boys came from a very great spread of schools. Furthermore high school rank was given in deciles only, with students coming from but four of these, more than two fifths from the highest. Here too there is clear evidence that a combination of test scores and high school rank would yield an improved prediction, though the intercorrelations between the tests are so high that not much would be gained by including more than one test with the high school record.

High school records of scholastic achievement gain added reliability from the fact that they represent a composite of ability and effort. Their weakness, not corrected entirely by the practice of rating the high schools on past performance, is the diversity of standards and requirements among different schools. Universal objective tests, particularly achievement tests, offset this weakness but introduce another springing from the divergence in the quality of instruction in different schools. A boy with a fine mentality may do badly on a test because he has been poorly taught, or because he has not been extended by his teachers or his competitors. Tests of the aptitude type can complement these, in that they give a measure of intellectual capacity more independent of the

quality of instruction and competition. In a sense they are forward looking, where the others look backward, and gain their value as past performance indicates future prospects. Unfortunately there is available at present no extensive study involving tests of these two types with good school records to yield a combined prediction, though there are a few isolated examples.* The scholastic aptitude test of the College Entrance Examination Board, together with a number of mathematics tests, has proved useful for institutions using them. Predictions at Yale, on such a basis, using Scholastic and Mathematical Aptitude, College Board subject matter exams, and adjusted high school rank, correlated as high as 0.75 with freshman averages, between 0.5 and 0.6 with performance in restricted areas.

Results at Harvard are similar. Most important is the conclusion that, though certain general suggestions can be made, each institution has its own peculiar problems, which can be solved best by a study of its own records, implemented by the use of such standard tests of achievement and aptitude as seem to fit best the local conditions.†

This report should not close without acknowledgment of the contribution of President Cullimore, of the Newark College of Engineering, who made possible the survey, provided clerical and other assistance as well as financial support, and was ever ready to give a sympathetic ear to suggestions; and of the contributions of Dean R. L. Sackett, who guided and advised without restricting freedom of action; and finally of the assistance and advice of many at the Newark College of Engineering, notably Mr. Edward W. Rice, who managed much of the detail work of the survey and contributed lavishly of his time, energy, and ideas.

* The American Council on Education Psychological Examination, though widely used, scarcely fills the need for a predictor for engineering schools.

† See the report of the Committee on Student Selection and Guidance, JOURNAL OF ENGINEERING EDUCATION, November 1941. On page 238 will be found a list of testing agencies. Earlier pages discuss briefly some of the tests there listed.

PERSONAL DEVELOPMENT—TEN YEARS AFTER *

By J. E. WALTERS

Vice President, Revere Copper and Brass Incorporated

In a democracy personal development is a personal matter of free choice. A person can develop as he sees fit or as he is fit. Everyone may vary in ability, but unless each takes the responsibility of developing himself, he is free to waste himself and his abilities away. Similarly, this is true with the engineer ten years after graduation. In normal times, ten years after finishing school the average engineer is making about $3000,† has a home on which he is paying installments, has a wife, two children, a dog, has fairly steady work and is reasonably happy. However, he is on a plateau of accomplishment and does not have very much ambition to improve himself or to enter into the social and political life of the community. He can't understand why the labor union in his plant doesn't like the labor-saving device he has invented, and why the president of his company wants him to leave his nice new little home to attend conferences on engineering, to participate in the activities of his professional society, and to learn about the new things that are going on. The boss wants him to develop himself so that he can design the new mill that is under consideration, instead of working out the run-of-the-mill small designs.

In discussing this with a number of executives recently, they all agreed that the average engineer arrives at a plateau of learning and ambition about ten years after graduation, and that it is difficult to spur his ambition to greater accomplishment.

Although it may not be as bad as these executives contend, there is some truth in the fact that most engineers do not develop themselves personally after graduation as they could or should. Was it their college education in engineering? Perhaps the last depression had something to do with it. The companies who employ them may not be entirely without fault. But what can be done about it for the future?

* Presented at the 50th annual meeting, S. P. E. E. (Personal Development), *New York City, June 27–29, 1942.*

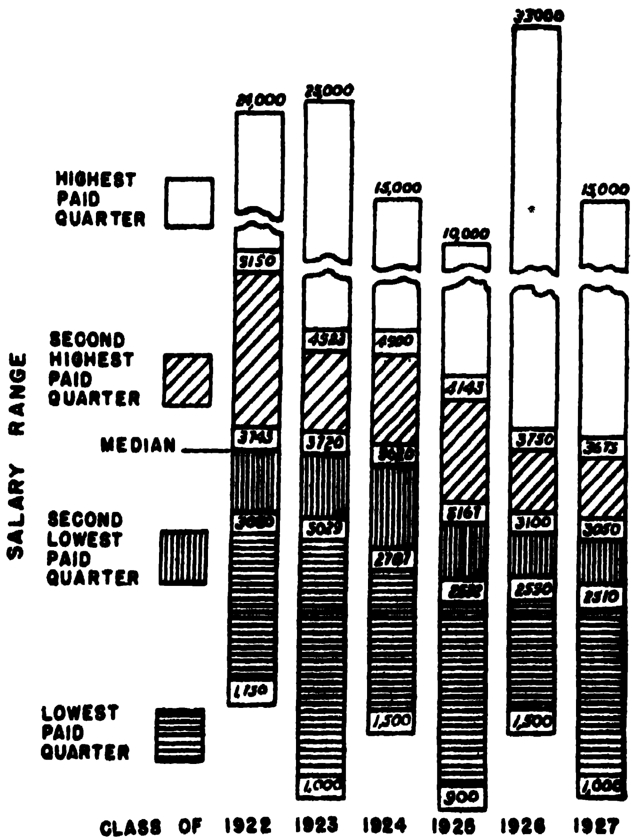
† See results of study by Dr. W. S. Learned, "The Wages of Scholarship," *Thirty-sixth Annual Report, Carnegie Foundation for the Advancement of Teaching, 1940–1941,* and appended study of Purdue University graduates *ten to fifteen years after graduation.*

We shall need better engineers for television than for radio, better ones for airplanes than for the railroads or automobiles, for magnesium than for steel or aluminum, and so on for the various new products and developments to come. These future engineers must also be more socially minded in the future than they have been in the past. They must be technical as well as sociological or psychological engineers. Yet, the better engineers of today say the young engineers should have more technology, and the sociologists and psychologists of liberal arts contend that these young engineers need more sociology, psychology, and business training than previously. What shall we do about it? Perhaps both are right for normal times. During the war when we apparently do not need so much culture, the cultural subjects in the engineering curriculum are being eliminated. But at the close of the war, why not give the engineer a liberal education of personal development, ambition, and culture first, and then his strictly technical education? In this manner, the liberal arts colleges would be satisfied and so would the technical universities. Perhaps, we would have better engineers who would be able to go beyond the plateaus of ten years after graduation and be outstanding engineering leaders which the future will need. Now, we must and will win the war, but in the future we must have bigger and better engineers—better personally, socially, and technically.

Status of Purdue University Alumni Classes 1922–27, Ten Years After Graduation (April 1, 1938)

From a Study Made By

D. C. MILLER and J. E. WALTERS



SALARIES (APRIL 1, 1938)

Fig. 1 presents the median, quartile, maximum, and minimum salaries of Purdue University graduates (classes of 1922 to 1927 inclusive) according to information returned in 1938.

FIGURE 8
COMPARISON OF HIGHEST AND LOWEST QUARTERS IN SALARY

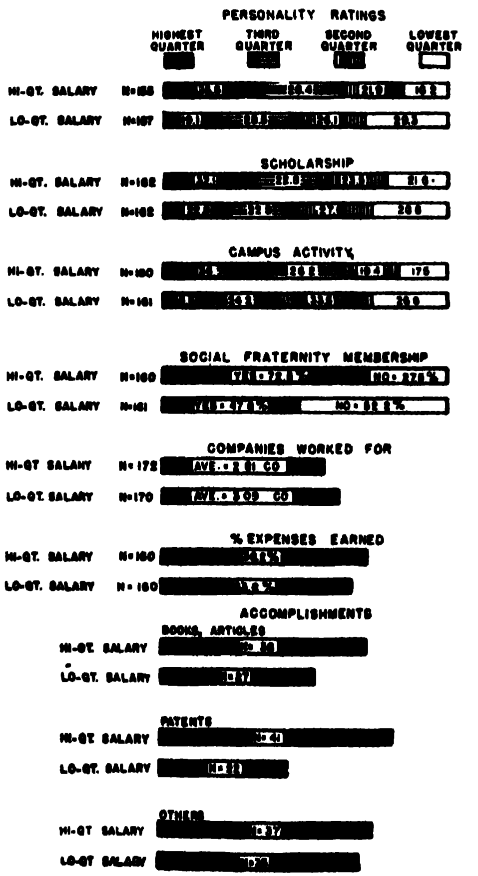


Fig. 2 presents the relationship between the highest and lowest quarters in salaries and personnel factors of Purdue University graduates (classes of 1922 to 1927 inclusive) as reported ten to fifteen years after graduation in 1938.

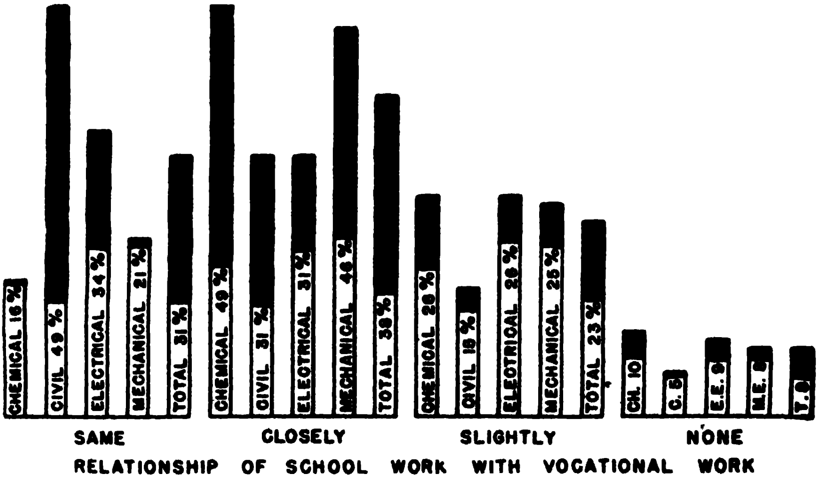


Fig. 3 presents the percentages of Purdue University graduates (classes of 1922 to 1927 inclusive) who, in 1938, were in work which was the same, closely, slightly, or not at all related to the course taken at the University.

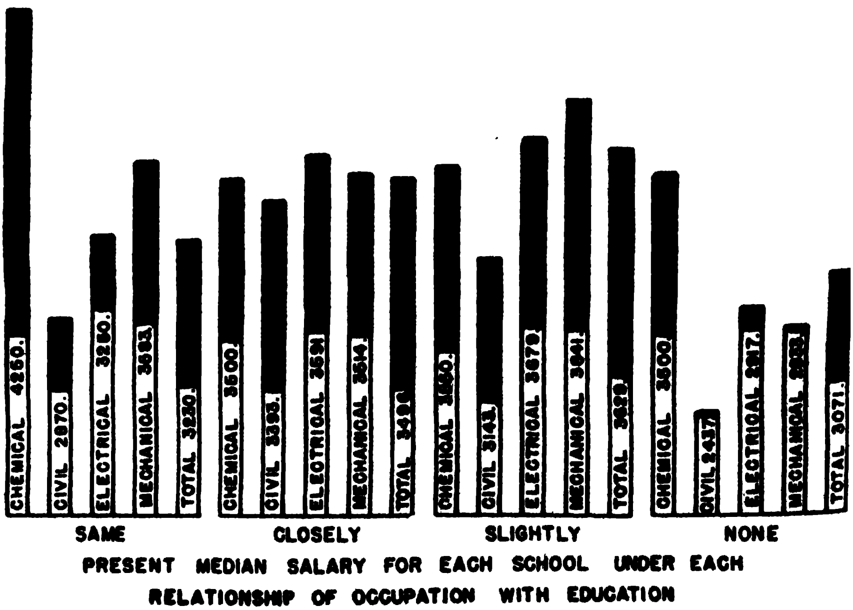


Fig. 4 presents the salaries of Purdue University graduates (classes 1922 to 1927 inclusive) according to the relationship of work in 1938 to courses taken at the University.

PURDUE UNIVERSITY ALUMNI—CLASSES 1922–27

PURDUE UNIVERSITY ALUMNI—CLASSES 1922–27

Percentage Employment in Various Classifications of Work

	Mechanicals	Electricals	Civils	Chemicals	Total	Median Salary
1. Accounting and Financing	4.5%	4.3%	4.5%	1.9%	4.1%	$3042
2. Administration	21.0	16.6	11.4	11.5	16.0	4156
3. Sales and Sales Promotion	25.5	17.0	10.0	14.4	17.6	3780
4. Design	7.5	8.5	10.0	1.0	7.6	3097
5. Construction and Maintenance	3.5	7.7	36.7	1.9	13.0	2972
6. Production and Operation	16.0	20.4	4.3	25.0	15.4	3681
7. Research and Development	8.5	10.2	1.9	31.7	10.3	3487
8. Farming and Farm Owners	0.4	0.8	0.0	0.0	0.4	
9. Field Workers	1.1	2.6	11.4	1.0	4.2	2944
10. Private Enterprise	3.3	5.1	6.2	1.0	4.3	6125
11. Teaching, Library, and Literary	5.7	3.4	3.3	7.7	4.7	2750
12. Medical, Hospital, Pharmacy	0.4	0.0	0.0	0.0	0.1	
13. Relief	0.4	0.0	0.0	0.0	0.1	
14. Graduate Students	0.0	0.4	0.0	0.0	0.1	
15. Miscellaneous	2.2	3.0	0.5	2.9	2.1	2800

Table 1 presents salary and personnel information of Purdue University graduates (classes of 1922 to 1927 inclusive) returned in 1938, ten to fifteen years after graduation. The above table gives the percentages employed and the median salary in each functional classification.

PURDUE UNIVERSITY ALUMNI—CLASSES 1922–27

COLLEGE NOTES

Clemson College.—The war effort has played an important part in the activities of the engineering staff during the past year. Numerous special courses have been taught in various fields and research of interest to government agencies has been carried on. Engineering, Science, and Management War Training courses have been given in Engineering Drafting locally and in four other cities; in Fundamentals of Radio locally and in five other cities; in Surveying and Mapping; in Safety Engineering in six cities. Engineering Defense Training courses have been given in Building Construction, Construction Methods, Structural Design, Reinforced Concrete, and Advanced Structural Design. In National Defense courses, several sections of Welding and Machine Shop have been taught locally both to men and women. Civilian Pilot Training programs have been fully carried out both in the part time and full time phases in elementary and secondary work. Pioneering research is in the progress in the use of bamboo as reinforcement for concrete with funds contributed by outside agencies and by the Kress foundation.

The engineering staff has lost several men to the armed services. W. M. Wachter, Instructor in Mechanics and Hydraulics, was called to active duty as second lieutenant in the Corps of Engineers. E. B. Therkelsen, Instructor in Electrical Engineering, was taken into the Signal Corps on his reserve first lieutenant's commission. Both these men had been deferred for more than a year. D. W. Bradbury, Instructor in Drawing, was called to Infantry and made Motor Maintenance Officer in the Armed Forces. A. M. Quattlebaum, Assistant Professor of Civil Engineering, took up his reserve commission as first lieutenant in Infantry and is assigned to invasion barge duty. H. M. Wiss, Instructor in Architecture, was taken in the draft. R. M. Anderson, Associate Professor of Architecture, has recently been commissioned Lieutenant in the Naval reserve.

Filling the vacancies caused by these are: F. R. Sweeny, Instructor in Mechanics and Hydraulics; J. R. Keeling, Instructor in Electrical Engineering; C. M. McHugh, Instructor in Drawing; C. C. Norman, Instructor in Civil Engineering; J. W. Linley, Instructure in Architecture. No appointment for Prof. Anderson's place has yet been made. Additional appointments are F. W. Sheldon, Instructor in Drawing and M. C. Moseley, Instructor in

Electrical Engineering. D. N. Harris, Assistant Professor of Engineering Drawing, has been forced by ill health to take a year's leave.

A unit of the Signal Corps was installed as a regular part of the ROTC, filling a long standing need for special military training along engineering lines.

The college has contracted with the Government to furnish training to specialized branches of the armed services. Details are not yet available, but it is expected that work will be in aviation and engineering.

Cornell University.—Herbert H. Williams, director of the Cornell University Placement Bureau since 1933, has been appointed assistant to Dean S. C. Hollister of the College of Engineering. Williams graduated from the Cornell School of Civil Engineering in 1925.

L. Donald Doty, employed since 1934 by the U. S. Army Engineers on various projects, has been appointed associate professor of hydraulic engineering in civil engineering.

Daniel F. Langenwalter and Stanley L. Schauss have been appointed instructors in the School of Electrical Engineering. Langenwalter, a graduate of Georgia School of Technology with the degree of B.S. in Electrical Engineering in 1941, has been at Cornell during the past year as a John McMullen graduate scholar working for his master's degree. Schauss is a graduate of Cornell with the degree of Electrical Engineer in 1927.

H. J. Loberg, C. I. Millard, and R. Y. Thatcher have been advanced from assistant professors to associate professors, and A. B. Credle, W. A. Johnson, T. A. Ryan, H. G. Smith, and J. H. Smith from instructors to assistant professors in engineering.

Assistant professor H. N. Fairchild has been transferred from the department of heat power engineering to the department of experimental engineering.

Two new departments were added to the Sibley School of Mechanical Engineering this fall. Professor Charles O. Mackey was named head of the Mechanical Engineering Laboratory, and Professor J. R. Moynihan head of the Department of Engineering Materials. These two departments will absorb the functions of the former Department of Experimental Engineering, and will also have additional functions demanded by recent advances in the two fields. Professor Mackey, who received his M.S. degree from Cornell in 1926, has been on the college staff since 1924, when he was appointed instructor in experimental engineering, later transferring to the heat power department. He was made an assistant professor of heat power engineering in 1929, and professor in 1936. Professor Moynihan also received his M.E. degree from Cornell in

1926, and took his M.M.E. in 1932. He was an instructor in experimental engineering in 1929–30 and 1931–37, and assistant professor from 1937–41, when he was given his present rank of associate professor.

Lieutenant Commander Arthur S. Adams, former assistant dean of the College of Engineering and officer in charge of the Diesel Engine course in the Naval Training School at Cornell, is now located in Washington, D. C., where he was ordered for special duty with the Navy Department.

Chemical Engineering students moved into their new building, Olin Hall, this fall. This new building houses Chemical Engineering laboratories and classrooms for approximately 500 students, and was presented to Cornell by Franklin W. Olin, '86, president of the Western Cartridge Company. The building is dedicated to Franklin Olin, Jr., '12, who died in 1921.

Missouri School of Mines and Metallurgy.—The history of this school is the product of ten years of research, collection of data, and editing. Careful documentation and thoroughness of treatment are striking characteristics of the work. It was edited by the Phelps County Historical Society, Mid-State Printing Co., Jefferson City, Mo., 1941, 1020 pp.

The contents of the first seven chapters can be summarized by saying that they give a view of the school as it now exists, a resume of the School of Mines' practical service to the state and nation, a sketch of the period of general industrial development of Missouri, and a rather detailed record covering the period of legislative establishment of the School. Particularly interesting and informative is the chapter dealing with the general industrial development of the state and the influence of this development on the founding of the School.

Chapters 8 to 19 cover the administrations of the first twelve directors of the School, 1871–1941. In general each administration is treated under the following topics: "biographical sketch of the director; details of the School's departmental organization; names and status of the Faculty members; the educational policies in force; the numbers of students and graduates, with the number and kinds of degrees awarded; the evaluation of the various technical and academic curricula; a statement of financial problems, legislative appropriations and fiscal affairs; and an outline of the particular problems and achievements of the administration."

In this section we witness the birth (under the ægis of the Morrill Act), the growing struggles, and the development of this lusty infant as it passes through adolescence to young maturity. The year 1915 marks the coming of age of this division of the University of Missouri. At that time the state legislature enacted a

bill directing, that the School of Mines and Metallurgy "shall confer the bachelor of science and professional degrees in mining engineering, in metallurgy, in mechanical engineering, in electrical engineering, in chemical engineering, in civil engineering, and the degrees of bachelor and master of science in general science." Thus by official act of the legislature the School's position as an institute of technology was confirmed.

The last chapter is devoted to a summary and conclusions; a roster of graduates appears as an appendix. The omission of an index is not as serious a defect as might be thought because there is an extensive table of contents and topical index.

The editors have ably performed a task of great magnitude in making possible this rather remarkable history. The Phelps County Historical Society has made a valuable contribution to the history of engineering education in this country.

SECTIONS AND BRANCHES

The Winter Meeting of the **Middle Atlantic Section** of the S.P.E.E. was held at The Cooper Union in New York City on Saturday, December 5, 1942. In spite of the difficulties of transportation, the meeting was very well attended. Registration showed 209 men present and 31 women. These figures showed a representation of 26 colleges in the Section and 13 industrial firms. Concurrent with the meeting of the Section, the Engineering Schools Librarians Committee of the Middle Atlantic Section held a special meeting during the morning session.

The business meeting of the Section was opened by the Chairman, Dean J. S. Morehouse of Villanova College. After his introductory remarks, Dean Morehouse introduced the Director of The Cooper Union, Edwin S. Burdell. Dr. Burdell cordially welcomed the Section to Cooper Union and expressed the desire that the day spent there would be both pleasant and profitable. In his welcoming remarks he indicated that the American colleges are facing certain vital facts and that serious attention should be given to their solution. Among these are:

1. The drafting of all students regardless of professional standing.

2. A few schools with dormitories will be selected by the Army and Navy for war training. He expressed regret that in this program the indications are that our schedules will be taken over completely by the military authorities.

3. He regretted the tendency of colleges to lean more and more heavily on the Government for special grants and student funds. In accepting these grants, the colleges must be more and more influenced by the Government. He indicated that schools that ask for financial help must, as a result, take on more and more Government supervision. He felt that this Government control was rapidly being accelerated.

4. He expressed a word of caution in regard to the problem of accepting women in the profession. He indicated that this might lead to ill will against the engineering colleges, since at the end of the emergency, a definite tendency would exist to discontinue the admission of women to engineering colleges. He therefore suggested caution in encouraging women to take engineering courses at the present time. In conclusion he definitely felt that we are facing a crisis at this time and a careful study of our progress is very vital.

After Doctor Burdell's address, the Chairman called to order

the business meeting of the Section. The Secretary's report of the Spring Meeting held at Princeton, New Jersey, was presented and accepted as read. The Treasurer reported a balance on hand, as of December 1, of $154.90.

The Chairman read a letter from the National Headquarters requesting that a delegate be appointed to represent the Section on the National Nominating Committee. He named the following Nominating Committee to select a delegate for the Section: Professors Billings, Walter and Fraim. The Committee placed in nomination Dean G. F. Bateman, Cooper Union, who was unanimously elected.

The next order of business was the election of the officers of the Section for the year 1943. The Nominating Committee, appointed at the Spring Meeting and consisting of Professor King, Dean Daggett and Professor Thatcher, placed the following members in nomination for offices for the year 1943: For Chairman, Professor Hale Sutherland, Lehigh; for Vice Chairman, L. A. Rittenhouse, Haverford; for Secretary-Treasurer, Frank D. Carvin, Newark College of Engineering. There being no further nominations for offices, the Secretary was instructed to cast a ballot electing the above candidates.

Dean Bateman brought up the question of listing the members of the Section on addressograph plates. Since the membership includes some 700 individuals, it was felt that it would greatly help in arranging the meetings held by the Section to have their names listed on addressograph plates. After considerable discussion, it was duly moved that the Treasurer be authorized to obtain addressograph plates of our membership.

As a final item of business, the Chairman called on Doctor Scott for a few remarks on the activities of the ECPD in regard to the young engineer. Doctor Scott briefly reviewed the activities of his committee on accrediting and professional standing of engineers and the joint action of various engineering societies. He cautioned the Section against any decrease in emphasis on college accrediting during this war period.

During the noon luncheon a special committee composed of the officers of the Section and the deans of the various colleges met to discuss a memorandum presented by Dean Newman of the College of the City of New York regarding the drafting of engineering students. After considerable discussion the Committee agreed to present Dean Newman's suggestions to the Section in the afternoon meeting.

After lunch at the Hotel Holley, the group moved to Washington Square Park where Dean Bateman placed a wreath on a monument erected to the memory of Alexander L. Holley. The monument

features the following inscription "In Honor of Alexander Lyman Holley, foremost among those whose genius and energy established in America and improved throughout the world the manufacture of Bessemer steel, this memorial is erected by engineers of two hemispheres."

At the afternoon session the Chairman introduced Henry T. Heald, President of the Illinois Institute of Technology and President of the Society for the Promotion of Engineering Education, who gave a talk on the topic, "Recent Developments in Army and Navy College Training Programs."

Dr. Heald reviewed the history of the engineering college executives and government policies as they relate to full-time students since Pearl Harbor. He mentioned the conference of college presidents held in Baltimore, January 3 and 4, and a later meeting of the same group in July. He brought out the many changes in the status of Army and Navy recruiting since the inception of the war and featured a statement of policy issued by the Manpower Commission on August 20, selecting the following two points as significant: 1. That all able-bodied male students are destined for the armed services; the nature of the training to be specified by the Army and Navy for their respective groups. 2. The Manpower Commission stated that it may be necessary to select draftees down to eighteen years of age, and any plan for student war training must take this possibility into consideration. The Manpower Commission also indicated that its division of professional and technical personnel, under the direction of Dr. E. C. Elliott, would function as a central agency to advise with Government departments and higher educational institutions regarding utilization of facilities and adjustment of educational programs within the war effort.

During the past summer, the American Council on Education appointed a new committee on Relationships of Higher Education and Federal Government under the chairmanship of President Day of Cornell University. This committee offered its services to the Joint Army and Navy Personnel Board and the War Manpower Commission and this offer was accepted.

On September 10 Secretary of War Stimson dropped a bombshell into the college world by announcing that enlisted reservists would be called to active duty at the end of the term in which they became of Selective Service age. At the same time the Navy indicated that it had no intention of making any radical changes in its announced college reserve plan. At a meeting of the American Council on Education Committee on September 17 and 18 careful consideration was given to developments to date as well as to information obtained from numerous conferences with representatives of the Army and Navy and other Government agencies. The

Committee recognized the need of an over-all plan for college training for military service and war industries, but concluded that the tactical situation made such a plan impossible at that time. The Committee formulated a plan for an enlisted training corps in the Army, Navy, Marine Corps and Coast Guard as follows: 1. That a training corps for military service be established at designated colleges and universities, open to all male high school graduates or others of equivalent education over seventeen years of age, who meet competitive standards, up to quotas to be established by the respective armed forces. Selection of candidates for enlistment to be made by appropriate military authorities in co-operation with the institutions. 2. Enlisted candidates may exercise choice in the selection of an institution within limits of quotas and establishment of programs by the armed forces. 3. Enlisted candidates shall pursue year-round curricula extending four semesters or the equivalent in length agreed upon by proper military and institutional authorities. Upon completion of this basic training, they may be assigned for further professional and specialized training. 4. Enlisted candidates shall receive base pay and subsistence while attending colleges and universities as members of the corps.

This plan was submitted to the War and Navy Departments and was made the basis for discussions in several conferences. It became clear that the military services were thinking primarily in terms of training for the technical and professional fields; such training to be abbreviated as much as possible. It was also apparent that there would be certain essential differences in the plans adopted by the Navy and Army; namely, that those men assigned to the Army plan would be selected after the completion of 13 weeks basic training, while those accepted for the Navy would be admitted directly from high school. More specific details of these new programs will be made public at an early date.

The S.P.E.E., at a recent meeting of the administrative officers, authorized the appointment of a special committee to work with the armed forces. This committee, working with the American Council on Education Committee, has already submitted the names of a panel of more than 100 experts in the various fields of engineering from which the Army and Navy may choose consultants for the preparation of engineering curricula. In Dr. Heald's opinion the plans which are developing have considerable merit. They will, if properly operated, permit the selection of the country's best qualified young men without regard to financial resources and thus permit young men of superior ability to be trained for officers and specialists. This should adequately meet the needs of the military forces.

The requirements of war industries present another aspect to the problem. With the lowering of draft age to eighteen, nearly all of our engineering students will be in the Army unless Selective Service procedures are changed. The S.P.E.E., in common with several other engineering societies, has recommended that provisions be made for the deferment of properly qualified engineering students in their freshman year. This recommendation is based on the assumption that war industry will require a continuing supply of men with engineering training. National Headquarters of Selective Service have, as yet, taken no action on this problem. They are awaiting information from the War Manpower Commission.

Dr. Heald feels that this situation is crucial, as it seems extremely unlikely that the demands of war industry can be met solely by the physically unfit or by the few women we may be persuaded, to enroll in engineering courses. Certainly it seems that until it may be clearly demonstrated that war industry is not going to need young engineers, at least a reasonable number must be allocated for this purpose. In order to be really effective, such a procedure would probably involve the establishment of an industrial training corps with definite quotas and definite responsibilities to be met by the institutions and by the students. Unless some such plan is put into operation in the very near future, the supply of engineers for war industry in 1943 and thereafter will be very small indeed.

Dr. Heald finished his talk with the expressed belief that the engineering college will be able to make the adjustments necessary for the success of this or any program. In the discussions which followed the talk, Dr. Heald indicated that he judged that the program would be in full operation in June 1943. He felt that all engineering branches would have a place in the training program, and he felt that the program would require the use of all engineering schools. Also he intimated that all sophomore and freshmen in college would receive 13 weeks of training after being drafted. He indicated that war quotas of engineering trainees had not as yet been made and that this is dangerous since the Army and Navy are able to present their needs while industry has no say at present.

The contemplated training programs will vary in length, averaging probably around six months of continuous training. The curricula of engineering colleges will be changed except in special cases.

The American Society of Mechanical Engineers recently passed a resolution asking for a deferment of engineering students in their freshman year, but the whole manpower problem is difficult and confused at present. The resolution may require that all training

be placed on a quota basis, but at the present time industry would suffer since it has not been effectively represented. This is a weak position, and industry should put pressure on the Manpower Commission.

Following Dr. Heald's talk, Dean Newman of the College of the City of New York read a resolution which he asked that the Middle Atlantic Section of the Society for the Promotion of Engineering Education endorse and that the same be forwarded to the Manpower Commission.

This resolution set up a program for the training of engineering personnel for both the armed forces, the war industries and for civilian services. The program recommended a technical training course not to exceed a total of 27 months. During this program students doing unsatisfactory college work would be dropped at the end of each semester and would become liable under Selective Service. The program also considered the allocation of students. After a short discussion of this resolution from the floor, Professor Reed made a motion that the Middle Atlantic Section of the S.P.E.E. pass a resolution to be forwarded to the Manpower Commission endorsing the resolutions of both the American Society of Mechanical Engineers and the American Institute of Chemical Engineers which had already been forwarded to the Manpower Commission and that a copy of Dean Newman's plan be also forwarded to the Manpower Commission to support our resolution. This motion was passed by vote, if not unanimously.

Dean Bateman of Cooper Union then recommended a change in engineering training curricula by suggesting a group of subjects within blocks, each block being complete and separate within itself. He suggested three semesters of subjects, providing a fundamental scientific foundation in the first block. In the second block, three semesters of basic engineering subjects were recommended and in the third block, two semesters of departmental engineering specialization. He estimated a probable distribution of trainees based on each and also suggested that women might be recruited and fit well into both the first and second block within this program.

We next listened to an address by Lt. Colonel H. F. Schwabacher of the United States Army on the topic, "Replacement of Men in Industry by Women." Colonel Schwabacher is connected with the manpower branch, Civil Personnel Division of the War Department. Colonel Schwabacher told the Section that the Army was facing a shortage of every-kind of personnel at both college and labor levels and endorsed the replacement of men by women within industry. He outlined what had been accomplished by both England and Russia in this matter.

Colonel Schwabacher stated that the allocation of personnel is a serious problem, that certain work can be done only by men, that

combat service needs special physical capacity and that within the armed services 70 per cent are specialists. He said that he recognized that industry must also produce if the war is to be won. The needs of the Army are not as yet known, but probably every physically qualified man above eighteen may be ultimately needed in the armed forces, and if such a man is not in the Army, he is merely loaned to industry, to society, or to his family. Colonel Schwabacher intimated that he felt that within the next year our industrial labor group would be increased by five million persons and the armed forces by between three and four million persons. These replacements must come from those who are not within industry at present, and women seem to be the solution.

The Army normally thinks in terms of those below college level. Colonel Schwabacher indicated that both industry and the armed forces desire trainees from the lower blocks of Dean Bateman's program. He said the draftees could be trained in four months if they are suitable timber and that at the present time within the Army a platoon commander is being trained within nine months instead of six years. He indicated that engineering schools are virtually devoid of women.

Colonel Schwabacher felt that if sufficient inducement were made to women to enter industry, that many would take advantage of a four, six or eight months' training program intended to train them for engineering work. He felt that the money might prove attractive and that the matter might successfully be approached from the patriotic angle. He felt that unless some comprehensive training program for women is developed and carried out, it may be necessary to deplete our armed forces and that that situation would not be healthy.

A third talk was given by C. Wilson Cole, Supervisor of the Engineering Personnel Bureau of the Curtiss-Wright Corporation, in which he outlined their program for the training of women for technical positions within industry. He presented a brochure, copies of which were placed in the hands of each individual present, outlining this program. The program endeavors to recruit young women from women's colleges and other walks of life to enter a special engineering training program of ten months duration. These trainees will be sent to seven selected colleges and will receive a salary from the Curtiss-Wright Corporation during their training.

Mr. Cole expressed the thought that girls completing ESMWT courses are not the full answer to industry's needs and stressed the fact that, for many purposes, additional engineering training is absolutely required. He said that both the armed forces and industry are moving toward vocational training and that schools must assume their responsibility in this training program.

During the discussion which followed Mr. Cole's talk, Dean Disque of Drexel Institute suggested that, in his opinion, a slight modification in the ESMWT program is all that would be required to solve the woman training program and this modification is, namely, that institutions should be fully compensated for the cost of carrying on this program.

The minutes of the afternoon session were taken by Professor H. E. Walter of the Newark College of Engineering in the absence of the Secretary. The meeting adjourned at 5:10 P.M. to be reconvened at the dinner held at the Hotel Breboort.

At the dinner meeting of the Section, attended by the men and women of the Section, Chairman Morehouse introduced Dr. Gano Dunn, President of The Cooper Union, as the speaker of the evening. Doctor Dunn spoke on some of the general problems of education. He stated that during the course of a year one person in four hundred thousand who had been educated must die. Also, some two and one half million people are born each year. It is the purpose of education, therefore, to make up the loss in our educated personnel due to deaths during the year and to educate the new born. He emphasized the fact that education must be real both in formation and in its functional aspects. There must necessarily be a proper balance between these two.

He spoke briefly on the effect of so-called social security. Indications are that increased emphasis on social security are both good and bad for people. As long as social security is not used to dull the incentive element in our lives, most of its effects are beneficial. He mentioned the fact that production is the basis of all wealth and happiness and that people need to be educated to realize that wealth is obtained through production and not someone's profit based on some other person's loss. We should continue to stress the humanities in our engineering education. He cautioned against the ill effects of subsidies from the governments and the effect on our educational policy. He emphasized the fact that we must continually keep control of changes in our educational policies and curricula. He ended his remarks by expressing the pleasure of Cooper Union in entertaining the Section as its guest.

At the conclusion of the meeting, Chairman Morehouse expressed the appreciation of the Section to Cooper Union for its excellent hospitality. The arrangement of the meeting and the preparation of topics and speakers was excellent. Both the luncheon and dinner meeting were very well planned. It was the general consensus that the Cooper Union meeting was one of the most pleasant and instructive meetings presented by the Middle Atlantic Section.

FRANK D. CARVIN,
Secretary

NECROLOGY

Harold Monroe Raymond, president emeritus of Illinois Institute of Technology, died at his home in Grass Lake, Michigan, January 24, 1943, at the age of 70.

The second president of Armour Institute of Technology, Dr. Raymond, served from 1922 until 1932 as its executive. Upon his resignation in 1932 because of impaired health, Armour Institute elected him president emeritus. With the merger of Armour and Lewis Institutes in 1940, he was subsequently elected to the honorary position of president emeritus of Illinois Tech. During his thirty-seven years of active duty at Armour he was successively instructor, associate professor and professor experimental physics, principal of the Armour Scientific Academy (discontinued in 1903), director of evening classes, and dean of engineering. After the death of Dr. Frank W. Gunsaulus in 1921 he became acting president; in 1922 he was elected president.

Dr. Raymond was graduated from the University of Michigan with the degree of bachelor of science in engineering in 1893. After graduation he was employed in the engineering department of the Rockford Electrical Manufacturing Company, where he remained for a year. He then returned to Michigan for graduate study. In 1895 he was appointed as an instructor at Armour then in its second year.

He was a member of Tau Beta Pi, national honorary fraternity, a fellow of the American Association for the Advancement of Science, a member of the Society for the Promotion of Engineering Education. He served as editor-in-chief of the Cyclopedia of Modern Shop Practice, the Cyclopedia of Engineering, and the Cyclopedia of Mechanical Engineering.

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"A what?" The awed Nazi leans closer.

"A thermotrockle amfilated through a daligoniter," explains Johnny, beginning to sketch with his left hand.

"You see, the dornadyne has a frenicoupling and the amacmeter prenulates the kinutaspel hepulace—here—and the—."

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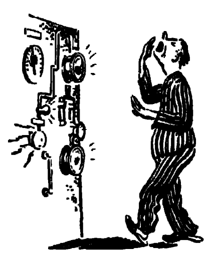

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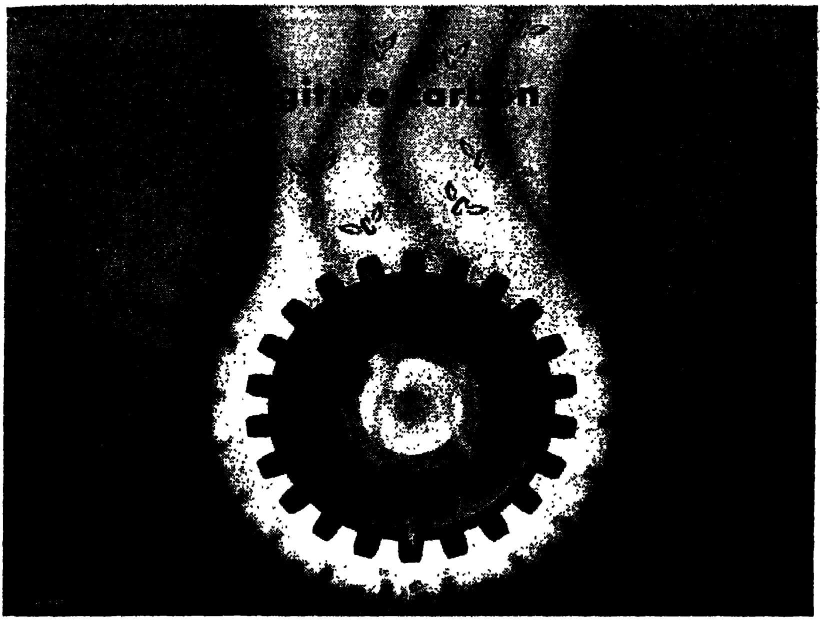

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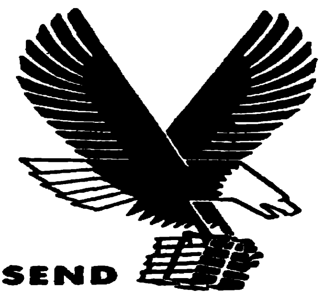

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50TH ANNIVERSARY MEETING, CHICAGO, JUNE 18, 19, 20, 1943.

At a moment when all attention focuses on the winning of the war and the greatest possible utilization of the nation's resources for the earliest conceivable accomplishment of that all desirable end, it is particularly fitting that the S. P. E. E. should hold its 50th Anniversary Meeting in Chicago, the city of its origin. It is Chicago today that in its war production typifies all that the S. P. E. E. stands for. In the unparalleled diversity of its war output, Chicago, more than any other city in the country, is proving what can be achieved when mechanical genius and education are put to the test.

Chicago has always been famed for the wide range of its industry. In peacetime, more than 9,000 different factories made it the output center for the greatest variety of manufactured wares of any metropolitan area in the world. From its shops in good years poured a mass industrial volume frequently exceeding $6,000,000,000 in value. In its army of skilled and semi-skilled labor, it possessed the nation's most valuable reservoir of manpower.

It has taken the war, however, to prove the real elasticity of Chicago industrial greatness. Today, according to official statements by the Army, the Chicago area not only is turning out the widest variety of materiel required by Uncle Sam's fighting forces, but it is the only district in the country that is producing every single item on the almost unending list comprising the needs of the Ordnance Corps.

While Detroit is leading in production of tanks, trucks, jeeps and all that goes into Uncle Sam's automotive efforts; while Los Angeles and other coast cities have the edge in aircraft manufacture; and while Philadelphia heads the list in building naval craft; Chicago is making some of each of these important categories and thousands of others.

Chicago to date has received more than 5¼ billion dollars worth of war contracts and subcontracts. Peacetime factories have been converted in many cases into 100 per cent war plants. Great new war plants such as those of Buick, Studebaker, Chrysler, Douglas Aircraft, American Torpedo, Aluminum Corp. of America and Bendix have been located in Chicago and put on a full scale operating basis. And without having to follow the example of other cities and go afield for its labor, Chicago has placed 700,000 of its

WACKER DRIVE

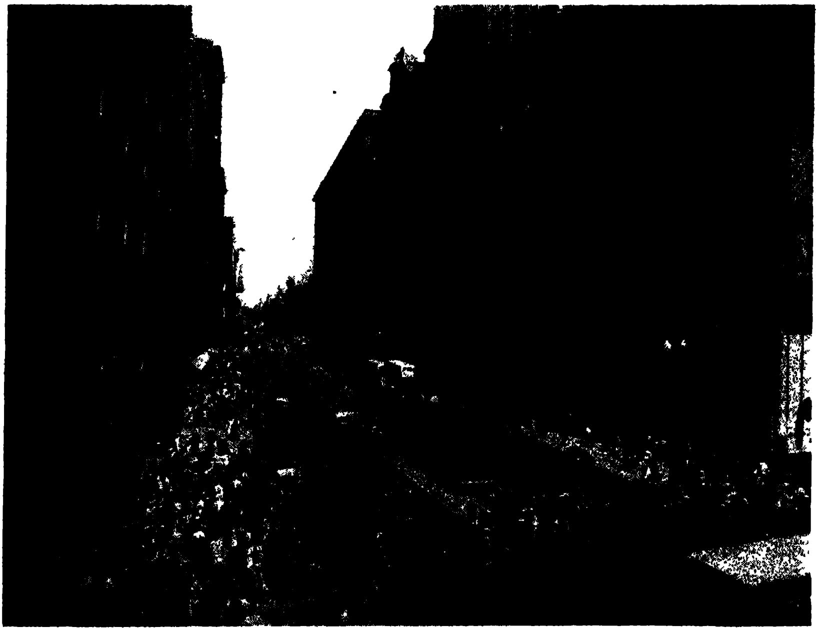
Skirting the south bank of the Chicago River is Wacker Drive, the first well known two-level street in America. Utilization of two levels has done much in solving the unusually heavy traffic problems which might otherwise beset this busy spot on Chicago's Lake Front where the Michigan Avenue Bridge connects the city's north and south sides.

The London-Liverpool Building in the immediate left foreground is located on the site of Fort Dearborn, original settlement of Chicago.

own men and women into war production jobs, without any marked ill effects to its essential consumer industries.

Briefly, Chicago has taken on one of the world's biggest war jobs, and it has taken it in stride mainly because in its 20 universities,

colleges and technical schools, in its long encouraged system of apprentice and inservice training, and in its leadership in developing new courses of education to fit white collar workers, housewives and physically rejected men and women for war work that have been copied by scores of other cities, it has, in war as in peace, applied sound engineering and engineering educational methods to its immediate problems.



STATE STREET—THE MAIN STREET OF THE NATION

Dozens of great department stores, specialty shops, theaters, hotels, and other great commercial establishments border State Street, Chicago's great retail center, whose buyers come from every section of the country.

Forgetting the unusual conditions precipitated by the war and looking at Chicago from a more normal viewpoint, the 3,000 square miles comprising the Chicago industrial area loom up a territory of huge steel mills, meat packing plants, machinery manufacturers, petroleum refineries, railroad car shops, chemical plants, and foundries—the basic industries forming the very foundation of American economic life.

In the aggregate its factories account for 8 per cent of the nation's manufacturing activity, although the population is only 4 per

cent of the country's total. The concentration of capital goods production is indicated by the fact that this area makes nearly one-fifth of the nation's rolling mill and steel products, 13 per cent of the electrical machinery, 27 per cent of the railroad cars, and refines 8 per cent of the nation's oil.

Chicago's stockyards and packing plants have been a magnet drawing thousands of visitors to Chicago for many years. The city's half-billion dollar meat packing industry handles and processes a tremendous number of animals. In 1940, for example, the slaughter of cattle under federal inspection totaled 1,358,248 head, while the hog slaughter was 5,692,010 head. Figures for calves and for sheep and lambs were 345,122 and 2,287,101 respectively. The

FIELD MUSEUM OF NATURAL HISTORY

Here on Chicago's Lake Front there awaits the visitor to Chicago one of the world's most complete exhibits of anthropology, zoölogy, botany and geology. Collections from all over the world of the prehistoric and modern make Field Museum a mecca for millions annually. The exploration parties continuously sponsored by the institution have left their footprints in every section of the globe.

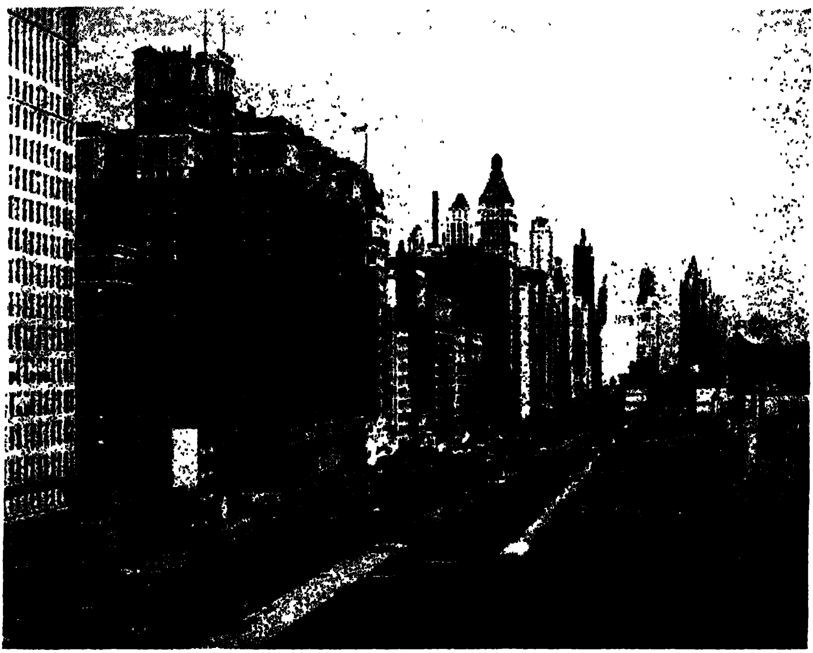
total for all livestock was 9,682,481 head. The packing plants themselves are models of efficiency. Research has developed hundreds of by-products, so that there is virtually no waste in the packing processes.

The railroad picture is fully as spectacular as that for the meat packing industry. There are 7,850 miles of railroad track in the Chicago industrial area alone. This is greater than the mileage in 39 of the 48 states, and is approximately equal to the total miles of track in all of New York State. Twenty-two trunk line railroads operate passenger and freight lines from Chicago, and, in addition, there are 15 belt and terminal railroads serving the city. Each day 369 through passenger trains enter or leave Chicago.

The significance of water transportation is indicated by the record of Chicago district lake traffic and the traffic on the Illinois

waterway which is said to be more than the traffic passing through the Panama Canal. Transatlantic vessels come direct to Lake Michigan ports via the St. Lawrence and the Great Lakes, while the new Illinois deep waterway provides a direct link with the Gulf of Mexico via the Illinois and the Mississippi Rivers.

In major lines of industry Chicago rivals Pittsburgh as a steel center, produces almost every known type of machinery, including



MICHIGAN BOULEVARD—CHICAGO'S FAMOUS FRONT DOOR

Few streets throughout the world are better known than Chicago's Michigan Boulevard with Lake Michigan and many of Chicago's famous parks and museums lining one side of the avenue and a typical cross section of the city's skyline furnishing the background on the other side.

the country's biggest output of diesel engines; is America's principal source of communicatioin equipment; outranks every other city in variety of furniture output, with 600 factories and 20,000 workers; tops $100,000,000 annually in the value of its textile manufacture; and leads in the variety and craftsmanship of its printing establishments. With its propinquity to so many sources of raw material and to the latent wealth embodied in the waste available from its packing plants, oil refineries and great industries,

it is only logical that Chicago should also be a major factor in the field of chemical manufacture.

Chicago can attribute its industrial preeminence not only to its strategical location, its climate and its development of the world's outstanding transportatioin network, but also to the foresight of its own citizentry. In its zoning ordinances, Chicago has always made ample provision for the creation of new manufacturing areas; in its public utilities it has been blessed with plentiful and economical power; in its program of public education it has given all encouragement to vocational training; and in its labor record it has kept its feet reasonably on the ground. Despite a few flare-ups, Chicago's average of lost-time strikes during the past decade has been almost

(ROSENWALD) MUSEUM OF SCIENCE AND INDUSTRY

Here preserved in Chicago for all time, in the famous Fine Arts Building of the Columbian Exposition of 1893, is being assembled the graphic history of man's technical developments. Typical of these exhibits is a real coal mine in actual operation.

50 per cent less than that of other industrial centers about the country. An intelligent municipal administration has coöperated in making the most of these many community assets.

For the visitor more interested in entertainment or cultural diversion than in the more prosaic economical conditions that have helped to make them possible, Chicago offers so many different attractions that it is no wonder that it won recognition as America's most popular convention meeting place. There is constant opportunity to see something new or unusual.

At the head of most visitors' lists as places to be seen are museums, and no one should miss the world famous institutions of which Chicago justfiably is so proud. Let's take the Field Museum of Natural History as an example. This great marble palace at the southern end of Grant Park is devoted mainly to anthro-

pology, botany, geology, and zoölogy. More than a million persons visit it each year. One of its latest attractions is "Hurwa and his daily x-ray." Hurwa is a mummy now, but some 2,800 years ago he was a minor official in Egypt. Still in his mummy wrappings, Hurwa stands behind a fluoroscopic screen and his ancient insides are projected on the screen by means of powerful x-rays. Other popular features at the Field Museum are the lifelike habitat groups of men and animals of other ages and civilizations.

Close by the Field Museum are the Adler Planetarium and the Shedd Aquarium. The planetarium, a rarity and one of the few of these unusual places in the entire world, reproduces the sky as of

SHEDD AQUARIUM

Newest and most complete aquarium in the world, with more than ten thousand specimens, ranging all the way from the walking fish of Africa to the weirdest exhibits of deep sea life, Shedd Aquarium, another of Chicago's great Lake Front institutions, has a visitor list of more than one million persons annually.

any day, season, or year. The heavenly bodies move along in their regular paths, and by speeding up the machine the movements that would require a day, a year, or even many years, can be shown in a few minutes.

The Shedd Aquarium, a $3,000,000 specially-designed building, contains one of the finest aquatic collections in the world. Strange fish from every quarter and ranging from tiny sea-horses to giant sharks and turtles are brought to Chicago in a custom-built railroad car.

The Art Institute of Chicago is the second largest art museum in the country. On the far south side of Chicago is the Vanderpoel Art Gallery featuring American painters and sculptors.

To S. P. E. E. visitors one of the most entertaining museums to be found is the Museum of Science and Industry, located in Jackson Park in an architectural masterpiece dating from the 1893 World's Fair. Many of the exhibits can be operated by the visitor, himself, to demonstrate workings of mechanical devices or to perform basic experiments in physics. Among the major attractions are an operating coal mine, a million-volt surge generator, a complete minia-

CHICAGO'S FAMOUS GOLD COAST

Here, stretching northward from the city's Loop along the shores of Lake Michigan, is shown Chicago's famous Gold Coast, residential area of many of the Middle West's most wealthy families.

ture railroad, a foundry, and many other exhibits covering physics, chemistry, agriculture, medicine, dentistry, pharmacy, transportation, civil engineering, and the graphic arts.

History is rather dry stuff under most circumstances, but not the way it is presented by the Chicago Historical Society in its handsome building located in Lincoln Park not far from the Loop. Through visual presentation in thirty-eight rooms it is possible to behold the most important periods in American history. The collection of relics is excellent, particularly the Lincoln collection, and

includes the actual anchor from Christopher Columbus' flagship, the Santa Maria.

The S. P. E. E. will meet in Chicago at a moment when the opportunity to enjoy the city's almost boundless outdoor attractions is at its best. A system of public parks reaching into every corner of the community and linked together by a 210 mile network of boulevards, the 34,000 acres of Forest Preserve encircling the city and including in their expanse of native woodland, rivers and lagoons the last word in potential enjoyment for the nature lover, the famous Brookfield and Lincoln Park Zoos and the equally storied Garfield and Lincoln Park floral conservatories, big league baseball, horse racing, outdoor musical entertainment, and the never to be forgotten street scenes in Chicago's unique foreign villages like Chinatown and the Ghetto—all offer a possibility for combining what promises to be an unusually interesting convention with an equally interesting and enjoyable vacation.

Theaters, nationally known radio stations, great metropolitan newspapers conducting regular tours for visitors, State Street with its well known department stores living up to its reputation as the "Main Street of the Nation," the Chicago Board of Trade and the Chicago Stock Exchange—they all await the S. P. E. E. delegates. And to top it off, there will be Lake Michigan, with its sandy beaches and lakefront boulevards stretching for 29 miles along the city's easterly border and its many convenient possibilities for bathing, yachting and fishing, proving why Chicago is often called America's greatest inland playground.

True enough, Chicago in wartime may seem to have foregone some of its previous color and you may find its streets crowded with thousands of soldiers, sailors and marines from the great military establishments now located all over its methopolitan district, but the odds are that in this throbbing metropolis, now giving its all to the conquest of the Axis, you will behold a more gripping and vivacious Chicago than ever.

You will like Chicago.

ACTIVITIES IN THE CURRENT ESMWT PROGRAM

BY GEORGE W. CASE *

In July of 1942 when the Engineering, Science, and Management War Training program was launched, our country was entering on a new phase of the manpower problem—a phase in which manpower has come to mean womanpower. During the Engineering Defense Training program of 1940–41 a few farsighted industries were concerned about the growing shortage of engineers; no great anxiety was felt, however, by the great majority. The 120,802 trained in EDT seemed quite adequate to most observers. In July, 1941, when ESMDT was instituted, the outlines of the manpower stringency were beginning to emerge; considerable interest in increasing the supply of male engineers, chemists, physicists, and production supervisors was met on all sides. Not until late in 1942, however, were employment officers able to overcome the prejudice against the employment of women for these jobs. Now, women are sought for nearly any job which they can perform. The present and projected size of our armed forces has determined the pattern of our labor supply. Indeed, in some areas, we are exhausting the supply of women qualified to profit by ESMWT courses.

Except for a moderate increase in size, and this marked shift of emphasis toward the training of those not liable for combat service, ESMWT is little different from ESMDT. Training is still directed toward specific activities to meet war needs within the four classifications established for ESMDT. More precise definitions of the field of training have been made from time to time and certain courses such as business communications, office machine operating, navigation, pilot training, radio code practice, camouflage, and meteorology have been definitely ruled outside the scope of the program's authorization.

Some 211 institutions had been authorized to operate 19,550 courses in one or more of the three college-level training programs by the end of February, 1943. Only 194 of these institutions were active in the ESMDT program, however, and only 7,872 ESMDT courses with enrollments of 438,503 were conducted. ESMWT, in contrast, by the end of its eighth month, numbered 222 approved

* Dean of the College of Technology, University of New Hampshire, absent on leave to serve as Director of Engineering, Science, and Management War Training in the United States Office of Education.

institutions among its participants: 155 approved for engineering, 206 for chemistry, 157 for physics, and 147 for production supervision. Between them these institutions had obtained approval for 9,324 ESMWT courses and had accepted enrollments totaling 372,528. Thus, it is evident already that this year's program will be somewhat larger than ESMDT.

The 372,528 ESMWT enrollments are still heavily concentrated in engineering courses, which alone account for 279,227 or about three-quarters of all enrollments. Production supervision courses are next in meeting needs of war industries, with 77,108. Chemistry and physics courses account for a little more than two per cent each. Between 20 and 25 per cent of all trainees enrolling in the current program are women.

The largest ESMWT enrollment of women has been for engineering drawing courses in which about one-fifth of the women have been enrolled, and accounting with approximately one-eighth of the total female registration. Other courses with appreciable female enrollments are: aeronautical engineering, personnel administration, inspection and testing, communications, surveying and mapping, engineering fundamentals, and analytical chemistry, in the order named. It is interesting to note that the courses with the lowest proportion of male enrollments are office management, analytical chemistry, inspection and testing, accounting, surveying and mapping, and fundamentals of engineering, in the order of increasing proportion of male enrollments. From one-third to one-half of the trainees in all of these courses are women.

Regarding the effectiveness of ESMWT in meeting shortages, we have much evidence in the form of reports and statements of its benefit to specific industries. A study of 1,897 completed ESMWT courses, casts light on another plane—the effectiveness of the instruction in preparing trainees. This study reveals that nearly 62 per cent of the 76,755 trainees enrolled had completed the courses satisfactorily—were prepared for the service contemplated when the courses were approved. The highest percentage of successful completions was 66.6 per cent of the 2,483 trainees enrolled in physics courses; the lowest was 57.6 per cent of the 1,442 chemistry trainees. Of the 56,071 enrolled in engineering courses, 61.5 per cent received certificates. The principal reasons for failure to complete courses satisfactorily were: Changed employment conditions, 8.5 per cent; unsatisfactory work in course, 4.7 per cent; and entered armed forces, 3.2 per cent. Other reasons, including sickness, poor attendance, too heavy an educational load, and failure to take final examination accounted, together, for the remaining 21.7 per cent. Certainly, these figures reveal no unhealthy tendency.

During the life of the program it has been necessary to organize certain courses to meet immediate nation-wide problems. Among these are the training of women for service as aircraft procurement inspectors, and Civil Service junior engineers, the refresher training of teachers of mathematics and physics, and the basic mathematical training of women and older men otherwise qualified for ESMWT engineering courses.

To train junior procurement inspectors for the Army Air Forces a course quite similar to the ordnance inspection course, but with the last 60 hours devoted to intensive training in one of four optional subjects coördinated with the type of aircraft on which the inspector plans to work, has been designed and offered at several institutions approved by the Air Forces. Trainees, who are selected by representatives of the Air Forces, are paid a training allowance of over 100 dollars a month.

The development of the refresher courses in mathematics and physics subject matter for teachers has been interesting. These courses were offered first during the summer, but enrollments in them were disappointingly low despite the need, throughout the country, for teachers to conduct greatly expanded instruction in those subjects. With the Fall opening of the schools it became apparent that not nearly enough teachers had received this training and that it would be practically impossible to enroll them in typical ESMWT classes during the school year. On October 22, 1942 Commissioner Studebaker circulated a letter to State and County Superintendents of Public Schools, announcing ESMWT correspondence courses in mathematics and physics—a new departure in ESMWT. These courses have been carefully designed in consultation with the staffs of institutions offering correspondence courses through their extension divisions. Institutions in 19 states have been authorized to offer these correspondence courses for teachers, using lesson sheets developed at the University of Wisconsin under the general supervision of ESMWT committee especially appointed for this purpose.

The junior engineer-supplemental training course was developed, in coöperation with the U. S. Civil Service Commission, to provide training for college women graduates, to prepare them for Civil Service engineering jobs. The course outline includes engineering computations and problems, engineering drawing, elementary mechanics of materials, surveying, and shop processes and methods. Over 1,000 women have been enrolled for this training since its inception.

Recognizing that at least two years of mathematics is necessary for entrance to college-level courses in engineering and for service in any job that may properly be classified as engineering, ESMWT

has established a qualifying course in mathematics to supplement the supply of women with this qualification, which is diminishing at a rapid rate. The course content was selected primarily to afford manipulative skill in algebra, knowledge of the fundamental facts of geometry, and a working knowledge of trigonometric functions. Those who progress satisfactorily in the qualifying course may enroll in engineering drawing or other elementary engineering courses before they have completed the qualifying course, carrying the two simultaneously until the mathematics is completed. It is hoped that this procedure will increase the number of women and older men who can successfully complete ESMWT engineering courses.

An increasingly important training problem has been the preparation of qualified men from industry to teach ESMWT courses. Such men have adequate grounding in the subject matter, but often lack knowledge of effective teaching methods. Several institutions, including the Pennsylvania State College, Yale University, Temple University, and the University of Santa Clara have prepared manuals of great helpfulness to persons undertaking instruction for the first time in the program. The Philadelphia group of institutions have rendered outstanding services in training instructors to teach college-level training courses.

Another and different set of problems has arisen from a recent reorganization of the War Manpower Commission. During the fiscal year 1941–42, the ESMDT program of the U. S. Office of Education was under the general supervision of the Chief of the Technical and Professional Training and Employment Division of the WMC, along with the National Roster of Specialized and Scientific Personnel. Executive order No. 9,279, dated December 5, 1942, authorized the reorganization of WMC under five main bureaus entitled Selective Service, Placement, Program Planning and Review, Manpower Utilization, and Training. The National Roster was placed in the Bureau of Placement while professional and technical training has been allocated to the Bureau of Training, together with the Apprentice Training Service, National Youth Administration, Rural War Production Training, Training Within Industry, and Vocational Training for War Production Workers programs.

The War Manpower Commission operates through 12 Regional Manpower Directors. In each Region the Bureau of Training is represented by a Regional Chief of Training who is a member of the staff of the Regional Director, along with representatives of the Bureaus of Placement, Program Planning and Review, and Manpower Utilization. Selective Service is represented on the WMC Regional Director's staff only in an advisory capacity, since the Washing-

ton headquarters of Selective Service deals directly, through the State Directors of Selective Service, with the local boards.

The WMC Regional Chief of Training is the chairman of a committee composed of representatives of the six training agencies. This committee is charged with the responsibility for estimating training needs and coördinating the work of the constituent agencies within its region. The actual operations of the various training programs are carried out by the agencies themselves, which are responsible to their Washington offices just as they have always been.

ESMWT maintains the same direct relations between the Washington office and the institutions which has always characterized it, and the same organization of regional committees under the chairmanship of the ESMWT Regional Advisers. The boundaries of ESMWT Advisers' regions have been changed slightly in some cases to make the twenty-one regions fit into the twelve War Manpower regions, and in each of those twelve regions an ESMWT Regional Adviser has been designated Regional Representative to the Bureau of Training of the War Manpower Commission. This ESMWT Regional Representative acts as the chairman of a committee of ESMWT Regional Advisers in cases where the WMC region includes two or more ESMWT regions. In every WMC region the ESMWT Regional Representative is the official representative of ESMWT on the committee headed by the Chief of Training, and official contacts between his agency and ESMWT are to be made through this ESMWT Regional Representative. He is to receive such reports from the institutions and the ESMWT Washington office as will enable him to keep the Regional Chief of Training fully informed as to the ESMWT program in the region, and he is expected to keep the ESMWT Washington office informed of all developments in his WMC region which might affect the approval of course proposals submitted by the institutions.

The Bureau of Training was formed by the War Manpower Commission with the thought that this coördination of the six training programs should result in a more comprehensive and efficient development of over-all training programs to meet the over-all needs of industry.

Increasing volume of instruction in ESMWT and complexity of operating problems have necessitated, likewise, a minor reorganization of the Washington office. Under ESMDT the country was divided into two geographical areas with a Principal Specialist in Engineering Education charged with the responsibility for approving course proposals in each area for the Director. In recognition of growing work-loads, a further division was made

on July 15th, establishing three areas to be operated in a like manner. More recently it has been necessary to introduce a fourth ESMWT area. The purpose of this reorganization is to expedite the processing, in Washington, of course proposals.

Among the operating problems of this year are those arising from wartime shortages of equipment, the necessity for reporting active enrollments more comprehensively to the War Manpower Regional Chiefs of Training, and the necessity for recruiting trainees from groups not liable for combat service.

Maximum use of equipment in ESMWT instruction must be obtained to meet the critical wartime shortage of such material. The policy recommended to secure such utilization has been, first, the design, whenever possible, of courses which can be given with the equipment already at hand and, second, the timing of starting dates and the staggering of class hours to keep duplication of equipment to a minimum and to secure the most continuous use of that which is available. Institutions have been asked to report all unused EDT and ESMDT equipment on hand which may possibly be made available to other institutions where the need for it is acute.

Institutions, with suitable shop and personnel facilities, which are able to obtain the necessary materials may build many items of equipment needed for ESMWT classes, including the cost in the 20 per cent allowance for cost of equipment and space.

The need of WMC Regional Chiefs for current enrollment data which will aid them in picturing the manpower supply of their regions as a whole has necessitated some adjustment of ESMWT reporting procedures. Certain reports from institutions are now made in duplicate, one copy being routed to the ESMWT Regional Representative for use in answering specific questions in the WMC regional offices. The active enrollment report has been revised also, to show, in addition to the active enrollment in each institution's program, the type of course at the institution which constitutes the major segment of its active enrollment and the number of active enrollments in this course. The ESMWT Regional Representatives will serve as channels for the collection and transmission of such information as WMC representatives may require, and it is hoped that no serious inconvenience to the institutions will be occasioned by the necessity for forwarding copies of these reports to the ESMWT Regional Representatives.

The recruitment of large numbers of qualified trainees who are not liable for combat service with the armed forces has become a major concern of ESMWT. If production goals are to be met, industry must be provided with replacements for the young men now called to the colors.

A recent report, prepared at the University of California points out that, the recruiting of college-type, employable women for ESMWT courses is becoming a major operating problem. Factors increasing the difficulty of this recruitment are: The small number of women with preparation in mathematics and science; the ease with which the college woman finds employment, often in jobs which she soon leaves because of their monotony; the competition of overseas adventures and uniforms offered by the WAACS and WAVES, and the high wages paid workers on assembly-line jobs; and the need for more intensive and concerted national promotion directed toward creating an acceptance of ESMWT among women.

The California report emphasized the following factors which influence qualified women to accept ESMWT training: Vigorous local promotion directed to patriotism and self-interest; the availability of training classes near home; the assurance of jobs upon completion of training; and adequate learner allowances for trainees in courses more than twelve weeks in length.

Aware of the importance of this last factor, many war industries are selecting young women for professional and sub-professional jobs, placing them on the payroll, and assigning them to attend ESMWT courses, in pay status, before entering on production work. Among the firms following this practice which have come to our notice are the Eastern Aircraft Division of General Motors, the Consolidated Aircraft Corporation, the Jones and Lamson Machine Company, the Willys Overland Company, the Toledo Scale Company, the Surface Combustion Company, the Electric Auto-Lite Company, the DeVilbiss Company, and the Koppers United Company. The Federal Civil Service is facing the necessity for meeting this competition and there is a good possibility that training subsidies now offered by Federal Agencies to ordnance and aircraft inspection trainees may be extended to other fields.

More and more, the participating colleges and universities are carrying on vigorous campaigns of local publicity, utilizing press, radio, and in some instances, tag-announcements on newsreels run by local motion picture houses.

The Washington office is undertaking promotion directed toward the recruitment of women, principally through the women's magazines. It is felt that these publicatins are highly selective in reaching the class which might provide desirable trainees and that their coverage is wide. Releases to date have brought in hundreds of inquiries from eligible women who have been directed to institutions near their places of residence.

The dramatization of ESMWT opportunities for women in a motion picture short has been proposed by at least two institutions, and the Motion Picture Division of the Office of War Information in Washington has been approached concerning the possibility of doing this. Lack of funds and trained personnel for this purpose makes it unlikely that ESMWT will enter this field of promotion, especially while more conventional publicity media which can be utilized at less cost are not yet saturated.

The success of recruitment efforts is attested by the growth of female ESMWT enrollments which are running well over 20 per cent of total enrollments, and expected to increase. The ratio of women's enrollments has risen to its present value from less than one per cent recorded in the EDT program of 1940–41. Of the 93,571 women enrolled in the three programs, more than 54,000 have entered engineering, science and management courses this year. In view of the unprecedented opportunities for qualified women in industry it can be expected that half of ESMWT enrollments may represent women before the close of the program. Perhaps older men and handicapped persons will comprise the major portion of the remainder.

Older men are already finding ESMWT courses in precision inspection and certain phases of production supervision effective in converting abilities acquired in such fields as salesmanship, law, and management of less essential enterprises for more direct participation in war production. Several hundred men in their forties and fifties have been placed in the aircraft industry as a result of ESMWT courses. Retraining courses for displaced executives are being operated on a small scale at a few institutions now, pending the recording of sufficient experience with this new kind of training to justify its expansion.

Estimates of the funds needed for the continuation of ESMWT during 1943–44 have been approved by the Bureau of the Budget and there is every reason to believe that the program will continue, substantially as it is at present, during another year. The development of special techniques for the retraining of handicapped individuals for war production may well be one of the operating problems of the near future. Some consideration is being given to problems in this field at present and a number of interesting suggestions have been received for the retraining of men discharged from the armed forces because of service-connected disability.

We in the Washington office take pleasure in utilizing this opportunity to commend the institutions whose energy and devotion have made possible the ESMWT program and extend our sincerest wishes for a continuation of the success which has attended their efforts.

ARMY SPECIALIZED TRAINING PROGRAM*

By A. L. H. RUBIN

BASIC PHASE ENGINEERING

Curriculum No. BE1

Term I	Hours per week	Term II	Hour per week
Mathematics: AST-406	6	Mathematics: AST-407	5
Physics: AST-304	7	Physics: AST-305	7
Chemistry: AST-205	3	Chemistry: AST-206	6
English: AST-111	3	English: AST-111	2
History: AST-133	3	History: AST-133	2
Geography: AST-163	2	Geography: AST-163	2

Term III	Hours per week
Mathematics: AST-408	5
Physics: AST-306	7
Engineering Drawing: AST-001	6
English: AST-111	2
History: AST-133	2
Geography: AST-163	2

ADVANCED PHASE ENGINEERING

Curriculum 4A1 and Curriculum 4A2

Term 4A

This is a refresher course and reviews the work in Mathematics, Physics, Chemistry, and Engineering Drawing of the Basic Phase.

ARMY SPECIALIZED TRAINING PROGRAM*

Mathematics: AST-406

Addition, subtraction, multiplication and division of polynomials. Factoring of following types:

(*a*) Perfect squares.

* Suggested texts following description of courses are not prescribed but are suggested as an indication of level and scope of the course. Each institution is free to choose its own equivalent texts.

(b) Difference of two squares.
(c) $x^2 + ax + b$.
(d) Factoring by grouping terms.
(e) Sum and difference of cubes.

Operation with fractions.

Evaluation of formulas. Include elementary mensuration of plane and solid figures.

Linear equations in one and two unknowns.

Exponents and Radicals.

Logarithms. Accuracy of computation is to be stressed. Five-place tables are recommended.

Quadratic equations in one unknown. Also include solution of linear-quadratic pair of simultaneous equations. Complex numbers.

Ratio, proportion and variation. Use illustrative material from plane and solid geometry.

Binomial Theorem.

Trigonometric functions. Recommended introduction of functions of a general angle immediately. Fundamental identities.

Computation on right triangles. Components of a vector.

Radian Measure. (Also introduce the mil.)

Graph of the sine and cosine function.

Trigonometric identities including addition formulas for sine, cosine and tangent. Double and half angle formulas.

Solution of oblique triangles. Insist on accuracy of computation.

Suggested Texts:

1. Brink, *Intermediate Algebra.*
2. Brink, *Plane Trigonometry.*
3. Crathorne and Lytle, *Plane Trigonometry.*
4. Curtiss and Moulton, *Essentials of Trigonometry.*
5. Peterson, *Intermediate Algebra for College Students.*
6. Rietz and Crathorne, *College Algebra, 4th Edition.*
7. Rosenbach and Whitman, *College Algebra.*
8. Rosenbach and Whitman, *Plane Trigonometry.*

Physics: AST-304

Motions of Translation: Constant and variable speeds, constant and variable velocities, vector relations, accelerations, uniform circular motion, motion of a projectile fired at an angle with the horizontal. Problem drill.

Forces: Newton's three laws, mass and weight, units vector relations, composition and resolution of forces, centripetal and centrifugal forces, center of gravity, momentum, conservation of momentum. Problem drill.

Rotation: Angular speed, velocity and acceleration, Newton's laws applied to rotating bodies, torque measurement, torque and angular acceleration relations, moment of inertia, angular momentum, conservation of angular momentum. Problem drill.

Statics: Conditions for equilibrium of a body under the action of a system of coplanar forces. Problem drill.

Work, Power, Energy: Potential energy and its measurement, kinetic energy and its measurement, kinetic energy of rotation, units, conservation of energy. Problem drill, measurement of mechanical power.

Molecular Forces: States of matter, diffusion, cohesion, adhesion, surface tension, capillary.

Friction: Types of friction, laws of friction between dry solid surfaces, viscosity of gases and liquids, limiting angle of friction, friction on an inclined plane, rolling friction, work done against friction.

Liquids: Characteristics of liquids, pressure, factors affecting pressure in a liquid, Pascal's principle, hydraulic devices, Archimede's principle, density, specific gravity, stability of floating bodies.

Gases: Atmospheric pressure, Terricelli's experiment, compressibility of gases, potential energy of a gas under pressure as compared with a liquid under pressure, Boyle's Law, fluids in motion, Bernoulli effect.

Elasticity and Periodic Motion: Moduli of elasticity, elastic and inelastic impact, simple harmonic motion, wave motion and types of waves, relations of wave length frequency and velocity, standing waves, reflection and refraction of waves.

Recommended Laboratory Experiments:

1. Measurement of lengths and angles, use of verniers and slide rule.
*2. Measurement of density and specific gravity of solids by use of analytical balance.
*3. Measurement of density and specific gravity of liquids, use of Westphal balance, calibration of an hydrometer.
4. The simple pendulum, relation of period and length, determination of g.
5. The compound pendulum, centers of percussion and oscillation measurement.
6. Simple harmonic motion, use of coil spring, determination of spring constant, period, and factors affecting period.
7. Determination of g, Free fall method.

* Equipment for experiments marked with asterisk is not likely to be available from supply houses. Institutions which already possess this equipment might assign these experiments. Others will be satisfied to arrange demonstrations.

8. Factors affecting torsion, use of cylindrical rods, torsional coefficient of elasticity.
9. Moment of inertia by torque and angular acceleration measurements.
10. Moment of inertia by measurement of period of a rotating body with elastic support (torsion method).
11. Young's Modulus.
12. Centripetal and centrifugal force measurement.
13. Coefficient of friction measurement.
14. Ballistic pendulum (Blackwood). Conservation of energy and momentum.
15. Potential energy and work measurement. Work done by a pile driver in driving a nail in a block of wood, average force, impulse.

Suggested Texts:

Two groups of texts are named, Group A being more definitely texts for engineering students, Group B more elementary texts requiring less mathematical preparation.

Group A	*Group B*
Anderson.	Eldridge.
Hausmann and Slack.	Foley.
Perkins.	Howe.
Robeson.	Kimball-Wold.
Saunders.	Stewart.
Shrader.	
Smith.	
Weniger.	

Chemistry: AST-205

Laws of Definite Proportion, law of conservation mass, equilibrium, structure of matter, valence, oxidation and reduction, periodic system, behavior of matter in the three states of aggregation, Faraday's law, solution phenomena (including electrolytes and ionization). Application of concepts and principles should be made to the study of elements, compounds and reactions.

The emphasis to be given to the above items would be determined in the light of the content of the physics courses given in the Basic Phase.

Suggested Texts:

1. Hildebrand, *Principles of Chemistry.*
2. Holmes, *Chemistry* (Unabridged).
3. Kendall, *Smith's College Chemistry.*
4. Schlesinger, *Chemistry.*

Mathematics: AST-407

Rectangular Coordinates. Distance and slope formulas.

The straight line.

Curve and Equation: The derivation of the equation of the curve from given conditions. A thorough discussion of the curve from its equation including such topics as excluded values, symmetry, vertical and horizontal asymptote, etc., as a preliminary to the drawing of the graph.

The Circle.

Translation and rotation of coordinate axes.

The Conics (not more than six or eight lessons).

Polar Coordinates. A careful drill in plotting of graphs.

Parametric equations.

Transcendental equations, include addition and multiplication of ordinates. Stress curves like $y = e^{ax} \cos bx$, etc.

Solid Analytic Geometry.

(*a*) Rectangular, cylindrical and spherical coordinates.
(*b*) Planes and straight lines.
(*c*) Second degree surfaces. Sketch by means of sections parallel to the axes.

Suggested Texts:

1. Love, *Analytic Geometry.*
2. Smith, Gale and Neeley, *New Analytic Geometry.*
3. Wilson and Tracey, *Analytic Geometry.*

Physics: AST-305

Sound: Nature of sound, sources, sound characteristics, resonance, beats, interference, Doppler effect, binaural effect, study of sounds produced by tuning fork, vibrating strings, organ pipes, loudness levels, decibel relations, elementary acoustics.

Kinetic Theory: Justification of Boyle's law by laws of mechanics, mean free path, molecular forces, relation of temperature to kinetic energy, derivation of $C = /3p/d$, mechanical explanation of cooling of a gas by expansion and cooling by evaporation.

Temperature Scales.

Types of thermometers.

Expansion of Solids: Coefficients of linear and volume expansion of solids, maximum density of water, expansion of liquids, thermostats.

Measurement of Heat Quantity: Units, calorie, B.T.U., specific heat, method of mixtures, heat of combustion.

Changes of State: Heat of fusion, heat of vaporization, supercooling, effect of pressure on the freezing point, regulation, sublima-

tion, evaporation, boiling, effect of pressure on the boiling point, variation of heat of vaporization with temperature.

Gas Laws: Thermal behavior of gases, changes of volume with constant pressure, changes of pressure with constant volume, the standard gas thermometer, general gas laws, free expansion, constrained expansion, specific heats of gases, isothermal and adiabatic processes, Van der Walls equation.

Vapors: Vapor pressure, saturated vapor pressure, variation of saturated vapor pressure with temperature, humidity of the atmosphere, triple point, critical point, liquefaction of gases, refrigeration, pressure volume relations for a saturated vapor, conditions under which the gas laws hold for a vapor.

Heat Transfer: Conduction, convection, and radiation, coefficient of conduction, Dewar flask, general radiation, general absorption, "black body" radiation, Stefan-Boltzmann law, Wien's displacement law, elementary quantum theory.

Heat and Work: First and second law of thermodynamics, work done by a gas expanding at constant pressure, work done by a gas in a Boyle's law expansion, mechanical equivalent of heat, transformation of heat into work, Carnot Cycle.

Nature of Light: Wave properties, corpuscular properties, photoelectric cell, and Young's interference experiments, velocity of light, Michelson's method, frequency and wave length relations, light sources.

Photometry: Candle power, illumination of a surface, light flux, measurement of candle power, inverse square relation.

Reflection and Refraction: Regular and diffuse reflection, plane mirrors, spherical mirrors, ray diagrams for location of images by spherical mirrors, relation of size of object and images, real virtual images, laws of refraction, index of refraction, deviation caused by a prism, total reflection, critical angle of incidence.

Lenses: Thin lenses, principal focus, object, image and focal distance relations, ray diagrams for lens combinations, aberrations.

Optical Instruments: Magnifying glass, telescopes, microscopes, eye, camera, field glasses, sextant, the electron microscope.

Spectra and Color: Dispersion, types of spectra and their sources, ultra violet and infra-red spectra, color of bodies, mixing pigments, Fraunhofer lines, theory of color vision, luminescence, spectral radiation, selective absorption.

Interference and Diffraction: Huyghens principle, Young's interference experiment, diffraction by a narrow slit, diffraction by a wire, Newton's rings and thin film interference, diffraction grating, X-rays and diffraction of X-rays.

Plane Polarization: Polarization by reflection, by double refraction, and by scattering, the Nicol prism, Polaroid, use of polarized

light in detection of double refraction caused by strains, rotation of plane of polarization, photoelasticity.

Recommended Laboratory Experiments:

1. Melde's experiment, standing transverse waves.
2. Kundt's tube experiment, velocity of sound in solids, standing longitudinal waves.
3. Velocity of sound in air, resonance tube measurements.
*4. Qualitative study of sound characteristics by use of phonodeik or oscilloscope.
5. Measurement of pitch by use of siren disk, pressure relations in standing sound wave (Rubens apparatus).
6. Measurement of coefficient of linear expansion.
7. Measurement of heat of fusion.
8. Measurement of heat of vaporization.
9. Measurement of specific heat.
10. Mechanical equivalent of heat.
11. Gas Laws, Boyle's and Charles' laws.
12. Variation of vapor pressure with temperature. Static or dynamic method.
13. Relative humidity measurement, sling psychrometer and dew-point measurements.
14. Photometry.
15. A study of thin lenses, aberrations, effect of stops, focal length measurements.
16. Simple telescopes, magnifying power.
*17. Index of refraction, spectrometer and prism method.
*18. Young's interference experiment.
19. Use of diffraction grating in wave length measurements.
20. Qualitative experiments on plane polarized light.

Suggested Texts:

Two groups of texts are named, Group A being more definitely texts for engineering students, Group B more elementary texts requiring less mathematical preparation.

Group A	*Group B*
Anderson.	Eldridge.
Hausmann and Slack.	Foley.
Perkins.	Howe.
Robeson.	Kimball-Wold
Saunders.	Stewart.
Shrader.	
Smith.	
Weniger.	

* Equipment for experiments marked with asterisk is not likely to be available from supply houses. Institutions which already possess this equipment might assign these experiments. Others will be satisfied to arrange demonstrations.

Chemistry: AST-206

Study of elements, their reactions and types of compounds, based upon their arrangement in the periodic table. The important common elements will be studied. What additional elements will be covered will be determined by their relative importance and the instruction time available.

Two 1-hour lecture periods a week. Demonstration will supplement the instruction by lectures. Occasional reference should be made to application of reactions to industrial processes.

Four laboratory hours a week will include time for quizzing of trainees and to give them an opportunity to ask questions.

Laboratory work will develop skill in, as well as knowledge of, laboratory procedures and will illustrate the principles of chemistry and the study of the important common elements taken up in the lecture periods of the course.

Suggested Texts:

1. Hildebrand, *Principles of Chemistry.*
2. Holmes, *Chemistry* (Unabridged).
3. Kendall, *Smith's College Chemistry.*
4. Schlesinger, *Chemistry.*

Mathematics: AST-408

Definition of Derivative. Finding the derivative by the increment process.

Differentiation of algebraic functions.

Applications of the derivative to:

(*a*) Equation of tangent and normal.
(*b*) Rates.
(*c*) Maxima and minima.

Differentiation of Transcendental Functions with further application of the derivative.

Differentials with applications to approximation, etc.

Integration of standard forms, integration by trigonometric substitution, integration by parts.

The definite integral with applications including areas and volumes.

Suggested Texts:

1. Granville, Smith, and Longley, *Differential and Integral Calculus.*
2. Love, *Differential and Integral Calculus.*
3. Miller, *Calculus.*
4. Sherwood and Taylor, *Calculus.*

Physics: AST-306

Electrostatic Phenomena: Brief study of constitution of matter, production of electric charges, two kinds of charges, the electron, force relations on charges, electrostatic induction, electric fields, electric potential, surface density, electric conductors and insulators, conduction in gases, ionization.

Magnetic Phenomena: Natural magnets, Coulomb's law, magnetic poles, magnetic fields, the magnetic field of the earth, theory of magnetism, magnetic shielding.

The Electric Current: Charges in motion, magnetic field of an electric current, simple electric circuit, electromotive force, resistance, effects of an electric current made use of in its measurement, Ohm's law, Joules' law. Problem drill on simple series circuit.

Resistance: Resistivity, temperature coefficient of resistance, resistance standards, resistance properties of alloys and pure metals, wire size, series and parallel relations.

Chemical Effects of an Electric Current: Faraday's laws of electrolysis, the primary cell, secondary cells, polarization, emphasis on $E = W/Q$.

Electromagnetism: Measurement of current by its magnetic effect, magnetic field about a straight conductor, magnetic fields about coils, forces on current leaving conductor in a magnetic field.

Electrical Measurements: A study of the measurement of I, E and R, galvanometers, voltmeters, ammeters, watt-meters, Wheatstone Bridge, Potentiometer, thermal electromotive force and its application in electric measurement.

Induced Electromotive Force: Faraday's experiments on electromagnetic induction, Lenz's law, electromotive force in a moving straight wire, the induction coil, simple transformer, simple generator, back electromotive force.

Capacitance: Charge and voltage relations, factors affecting capacitance, energy in a charged capacitance, capacitance in series and in parallel, current and time relations in a DC Circuit with capacitance.

Inductance: Fundamental idea of inductance, factors determining inductance, energy stored in the magnetic field of an inductance, mutual inductance, current and time relations in a DC Circuit with inductance.

Alternating Currents: Simple AC generator, effective value of an alternating electromotive force and current, capacitance and inductance in AC Circuits, power relations, power factor.

Thermionics: Edison effect, simple diode characteristics, triode characteristics, cathoderay oscillograph, X-ray production, the photoelectric cell.

Recommended Laboratory Experiments:

1. Electrostatic phenomena, a qualitative study of.
2. A study of the magnetic field about a permanent magnet, plotting of a field with location of neutral points.
*3. Use of the tangent galvanometers to determine *H*.
*4. The magnetometer and magnetic pendulum method of measurement of *H*.
5. The d'Arsonval galvanometer, sensitivity measurements.
6. A study of the effect of galvanometer shunts.
7. Wheatstone bridge, series and parallel resistance measurements.
8. Measurement of resistivity, direct deflection method.
9. Voltmeter and ammeter measurements in a simple series circuit containing a gravity cell.
10. Measurement of temperature coefficient of resistance.
11. Measurement of capacitance, series and parallel capacitances.
12. Joule's law, Barnes' constant flow calorimeter method.
*13. Bridge method of comparing inductances.
14. Faraday's laws of electrolysis.
15. Simple diode characteristics.
16. Triode characteristics.
17. Intensity of light effect on electric current of photoelectric cell.

Suggested Texts:

Two groups of texts are named, Group A being more definitely texts for engineering students, Group B more elementary texts requiring less mathematical preparation.

Group A	*Group B*
Anderson.	Eldridge.
Hausmann and Slack.	Foley.
Perkins.	Howe.
Robeson.	Kimball-Wold.
Saunders.	Stewart.
Shrader.	
Smith.	
Weniger.	

Engineering Drawing: AST-001

Use of instruments.

General machine drawing and technical sketching.

* Equipment for experiments marked with asterisk is not likely to be available from supply houses. Institutions which already possess this equipment might assign these experiments. Others will be satisfied to arrange demonstrations.

Basic geometric arrangements.
Arrangements of views.
Plan, elevation, auxiliary, section views, conventions, standards.
Dimensioning: Use of scales.
Size, location, tolerance and limits.
Reading of shop drawings, and accompanying specifications.
Fastening devices: threads, belts, nuts, screws, welds, etc.
Intersections and developments. (Sheet metal layouts.)
Elements of lofting and geometric principles of a short term nature and incidental to the above program.
Principles of duplications of drawings.

Suggested Texts:

1. French, *Engineering Drawing.*
2. Giesecke, Mitchell, Spencer, *Technical Drawing.*
3. Jordan and Hoelscher, *Engineering Drawing.*
4. Meadowcroft, *Aircraft Detailed Drafting.*
5. Schumann, *Technical Drafting.*
6. Svenson, *Machine Drawing.*

The Course in American History

This outline indicates the areas of instruction on which emphasis should be placed. It is not intended to prescribe the course of study in detail. Reliance is placed on the instructor's initiative and resourcefulness and on his judgment in utilizing materials and techniques of teaching.

OBJECTIVES OF THE COURSE:

It is important that each trainee completing the basic phase of the Army Specialized Training Program should have a sound knowledge and understanding of American History.

The objectives of this course are to give him:

I. 1. A sound knowledge and understanding of the origins of American institutions (social, economic, political, and military), tracing their roots to their Old World sources; of the Europe from which the colonists and later immigrants came, why they came and what they brought with them; of the resultant problems of adjustment.

2. A sound knowledge and understanding of the struggle for American unity and the emergence of American national consciousness; of the westward movement and the expansion of the American domain to its continental limits; of the growth of sectionalism, and the War between the States; of the subsequent reconstruction of the nation.

3. A knowledge and understanding of the emergence of the United States as a world power; of changes in national point of view which that development imposes on the people; of the responsibilities for international leadership which have been created and which America must assume; of our developing relationships with the nations of South America, Europe, and Asia.

4. A knowledge and understanding, through the foregoing, of the trends, movements, and events which have led to World War II; of the fundamental issues involved; of the problems and opportunities which will follow the conclusion of the War.

II. A sound knowledge and understanding of the growth of representative, constitutional government and political democracy; of the tripartite governmental powers; of the federal idea in operation; of states' rights and the trends toward centralization; of civil rights and liberties, and the civil responsibilities which accompany them; of these governmental principles and practices as instrumentalities for the establishment of the worth and dignity of the individual.

Comment:

No field of investigation and instruction is subject to wider variations of approach, development, and technique than that of history; in none has the instructor freer choice in the selection of basic materials, in determining the range or the absence of indoctrination, in providing the stimulus to independent thought on the part of his students. In such a controversial field, formalization into a fixed pattern is undesirable.

It is believed, however, that the objectives set forth above should be sought in a spirit unreservedly in consonance with the ideas and ideals for which the nation is fighting. This principle should similarly govern the distribution of the limited time available and the relative emphasis given the different areas of study.

Each trainee should be thoroughly impressed throughout the course with a sense of the personal responsibility which rests upon him (and upon every other citizen) to preserve and strengthen the American way of life. This involves the consideration of such characteristics of American life as freedom of opinion and speech, freedom of assembly and worship, equality of opportunity, and equality of justice under the law. It also involves consideration of the individual obligation of restraint in the exercise of these freedoms as it affects the common good.

Instruction should take a realistic middle-of-the-road interpretation of historical truths, avoiding the tendency on the one hand of belittling the importance of America's part in the world drama and avoiding, on the other, the tendency to gloss over the nation's

failures and shortcomings. Such procedure, it is believed, will develop in the trainee the rational and realistic point of view wanted in a man who is being trained for the battlefield.

Coordination of Courses:

The accelerated nature of the courses in English, history, and geography requires coordination of instruction and use of common materials so far as possible. Richness of content will be achieved by drawing freely upon the resources of all related departments. It is suggested that a central committee be established in each institution to coordinate these functions and achieve these ends.

The objectives of the course have been stated broadly to permit maximum latitude in development. The Army Specialized Training Division is prepared to serve as a clearing house for suggestions as to methods and materials of instruction used by participating institutions.

English: AST-111

The following material indicates the areas of instruction on which emphasis should be placed. It is not intended to prescribe the course of study in detail. Experience indicates that reliance can be placed on the capable instructor's initiative and resourcefulness and on his judgment in utilizing materials and choosing his techniques of teaching.

OBJECTIVES OF THE COURSE:

The end-product of the Army Specialized Training Program is an officer candidate who will, after further specialized training, function effectively in a position of command. He must, therefore:

1. Be a clear thinker.
2. Possess the skill of orderly, concise, and appropriate communication, both oral and written, including the ability to observe and report accurately.
3. Possess the ability to listen and to read understandingly.
4. Know the basic forms of military communication.

In view of the limited time available for instruction in English, it is particularly important that this instruction be reinforced by requiring trainees in all classes to write and speak with deliberation, clearness, and correct language.

It is urged that particular attention be paid to the development of the trainees' powers of reasoning, imagination, and communication, especially in relation to the study of American history and institutions by the use of biographies, historical works, and materials having historical content—for purposes of analysis, discussion, and expository writing. This should not be done, however, to the

exclusion of poems, short prose articles, and selections from works of notable English and American writers which present the correct native idiom.

The course, of thirty-six weeks duration, is the same for all basic trainees. Although the course is divided into three twelve-week terms, it is intended to provide continuous progressive training throughout the entire thirty-six weeks.

FRAMEWORK OF INSTRUCTION:

The following is a suggested framework of instruction, not confined to specific twelve-week terms, but continuing throughout the course:

1. *Reading.*

Close study of selected paragraphs to distinguish the central subject in each, the order in which facts are presented, the key sentences, the paragraph structure and the precision with which words are used.

Analysis of material to discern the continuing thought and distinguish the style of presentation, qualities of sustained interest, logic of development, major and minor ideas, cumulative power of persuasion, validity of conclusions.

Examination of current critical writing; analysis of material to detect strong and weak generalizations, true and false analogies, impartial and biased opinions, hypothetical and categorical premises, emotional and intellectual conclusions.

2. *Writing.*

Instruction and practice to develop conciseness in expression, without omitting essential material.

Instruction in proper usage; punctuation, grammar, vocabulary, and spelling.

Instruction in outlining and note-taking.

Practice in the accurate reporting of accurate observations.

Instruction and practice in expository writing requiring sound structure, logical development, and continuity of thought and emphasizing simplicity and lucidity of expression, with due emphasis on correct usage of the English idiom.

Practice in the preparation of reports ana'yses, and criticisms. Basic material for this feature of the work should be drawn from readings in this course and in considerable degree from all other courses in the program.

(A minimum of four hours instruction in the basic forms of military correspondence is required. The Commandant will collaborate in this instruction. Army Regulation 340–15 and "Orders," Instructional Pamphlet No. 1, published by the

Infantry Journal, may be used as basic texts for military correspondence.)

3. *Speaking.*

Instruction and practice in oral presentation. Development of self-confidence and the ability to think on one's feet. Development of sound habits of brevity, correct pronunciation and enunciation, conciseness of expression, and organization of material. Development of variations in emphasis through the correct use of such devices as volume of tone, acceleration and retardation of speed, and the use of the pause. Acquisition of adequate ease and fluency to speak extemporaneously, reasonably free from hesitation, forcefully and pleasingly, and coherently as to sentence and paragraph structure. Elimination of handicaps of speech such as the monotone, undesirable mannerisms and affectations.

Presentations should be so well organized as to impress themselves, in outline, on the listener's memory. They should be subjected frequently to criticism by the hearers in terms of the speaker's appearance, manner, adequacy, brevity, forcefulness, and organization of material. (See next section.)

4. *Listening.*

Development of concentration upon spoken remarks and the ability to understand what is said. Cultivation of ability to concentrate upon speaker's intended meaning and not to be diverted by idiosyncrasies of manner. Development of ability to repeat in listener's own words the context of speaker's remarks.

Instruction in both speaking and listening will be strengthened by frequent panel discussions on current problems.

The following is a list of suggested readings which will both provide material for the course in English and implement the study of the basic courses in history and geography. It is assumed that this list will be amplified as the instructor sees fit.

Acton, *History of Freedom*, selections.
Adamic, *From Many Lands*, selections.
Beard, *Old World and New*, selections.
Bok, *Education of an American*, selections.
Bradford, *History of the Plymouth Plantation*, selections.
Carnegie, selections on Anglo-American cooperation.
Churchill, *World Crisis*, selections.
Clay on Pan-Americanism.
Emerson, selections, "Self-Reliance," etc.
Friedrich, *New Belief in the Common Man*, selections.
Greeley, "Go West," editorial.
Hagedorn, *Life of Leonard Wood*, selections.

Hay, selections of "Open Door" policy.
Herring, *Politics of Democracy*, selections.
Holmes, *The Common Law*, selections.
Jefferson, *Notes on Virginia*, selections.
Lincoln's Second Inaugural and Gettysburg Addresses.
Lippman, selections on early Twentieth Century problems.
Locke, *Of Civil Government*, selections.
Macaulay, *History of England*, selections.
Mills, *Liberty*, selections.
Nicolson, *Peacemaking, 1919*, selections.
Paine, *Common Sense*, selections.
Parrington, *Main Currents of American Thought*, selections.
Roosevelt, selections, including the Four Freedoms.
Rousseau, *Social Contract*, selections.
Sandburg, selections on post-Civil War period.
Schurtz, selections on civil service reform and melting pot.
Tawney, *Religion and the Rise of Capitalism*, selections.
Thoreau, *Civil Disobedience*, selections.
Wilson, *Congressional Government.*
Wilson, selections on the New Freedom.
Whitehead, *Science and the Modern World*, chapter one.

ARMY SPECIALIZED TRAINING PROGRAM

Advanced Phase

CHEMICAL ENGINEERING

CURRICULUM No. ChE-1

Term 4	AST Nos.	Hrs. per wk.	Term 5	AST Nos.	Hrs. per wk.
Mathematics	401	5	Phys. Chemistry	404	6
Qual. Anal.	401	6	Org. Chemistry	405	10
Quant. Anal.	402	8	Unit Oper.	415	6
Phys. Chem.	403	5	Mechanics	401	6
Ind. Chem. Cal.	403	3			

Term 6	AST Nos.	Hrs. per wk.	Term 7	AST Nos.	Hrs. per wk.
Str. of Mat.	401	4	Unit Oper. Lab. II	418	8
Unit Oper. II	416	3	Chem. Tech.	406	7
Ele. of El. Engr.	401	8	Phys. Met.	410	5
Unit Op. Lab. I	417	7	Chem. Engr. Prob.	420	6
Thermodynamics	335	5			

ARMY SPECIALIZED TRAINING PROGRAM

Mathematics: AST-401

For description see Mathematics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Qualitative Analysis: AST-401

Prerequisite: Elementary Chemistry.

Training in the theory and technique of qualitative analysis. After experience with known samples, unknowns should be successfully analyzed. The lecture and recitation hours should permit the students to gain an understanding of the principles.

Suggested Texts:

1. McAlpine and Soule, *Qualitative Chemical Analysis.*
2. Noyes and Swift, *Qualitative Chemical Analysis of Inorganic Substances.*
3. Smith and Miller, *Qualitative Chemical Analysis and the Related Chemical Principles.*

Quantitative Analysis: AST-402

Prerequisite: Elementary Chemistry.

Standard methods of volumetric and gravimetric analysis of unknown samples. The lecture and recitation period is employed to explain the various procedures and to give practice in calculations.

Suggested Texts:

1. Hall, W. T., *Textbook of Quantitative Analysis.*

Physical Chemistry: AST-403–404

Prerequisites: General Chemistry, Mathematics through Differential Calculus.

Properties of gases, liquids and solids, elementary thermodynamics, solutions, electrolytes, colloids, thermochemistry, phase equilibrium, chemical equilibrium, chemical kinetics, electrochemistry, photochemistry, atomic structure. The principles should be profusely illustrated by many simple problems assigned to the students. The laboratory work would consist of about ten typical measurements such as molecular weight determination, vapor pressure, heat of solution, equilibrium constant, reaction velocity constant, binary liquid-vapor equilibrium, solubility, etc.

Suggested Texts:

1. Getman-Daniels, *Outlines of Theoretical Chemistry.*
2. Millard, E. B., *Physical Chemistry for Colleges.*
3. Noyes and Sherrill, *A Course of Study in Chemical Principles.*

Industrial Chemical Caulclations: AST-403

Prerequisites: Elementary Chemistry and Mathematics through Differential Calculus.

Weight and composition, stoichiometry, density and volumes of ideal gases and of gas mixtures, vaporization and condensation, thermophysics, thermochemistry, thermochemistry of industrial reactions and fuels, weight and heat balances of chemical and metallurgical processes. Emphasis on problems.

Suggested Texts:

1. Hougen and Watson, *Industrial Chemical Calculations.* This text includes a number of excellent examples and problems.

Physical Chemistry: AST-404

For description, see Physical Chemistry AST-403–404 listed under 4th Term.

Organic Chemistry: AST-405

Prerequisites: General Chemistry.

The subject matter of organic chemistry is fairly well standardized and there is no need to present a topical outline. Broadly speaking, it deals with the compounds of carbon—their preparation, properties and uses. It should treat the most important (from an industrial viewpoint) classes of aliphatic, aromatic, alicyclic and heterocyclic compounds. All through the course it is desirable to arouse the student's interest by reference to compounds of importance to industry and to point out important applications. A good example is synthetic rubber.

Laboratory courses are also thoroughly organized and consist in the preparation of typical compounds and some simple tests for identification of organic compounds.

Suggested Texts:

1. Conant and Tishler, *The Chemistry of Organic Compounds.*
2. J. F. Norrie, *Principles of Organic Chemistry.*

Unit Operations I: AST-415

Prerequisite: Physics, Mathematics through Integral Calculus.

Fluid flow, heat transfer, evaporation, filtration, crushing and grinding, and introduction to diffusional operations.

Suggested Texts:

1. Badger and McCabe, *Elements of Chemical Engineering.*
2. Walker, Lewis, McAdams and Gilliland, *Principles of Chemical Engineering.*

Mechanics: AST-401

For description see Mechanics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Strength of Materials: AST-401

For description see Strength of Materials: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Unit Operations II: AST-416

Prerequisite: Unit Operations I.

Distillation, absorption, extraction, and air conditioning and drying.

Suggested Texts:

Same as in Unit Operations I.

Elements of Electrical Engineering: AST-401

For description see Elements of Electrical Engineering: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Unit Operations Laboratory I: AST-417

One seven-hour laboratory period and one conference hour for one term. It is suggested that a part of each period be used for the computations as only 4 hours are allowed for report writing per laboratory period. Laboratory I covers subjects treated in Unit Operations I.

Thermodynamics: AST-335

Prerequisite: Mathematics through Integral Calculus, Physical Chemistry.

Definitions and fundamental concepts, first law of thermodynamics, second law of thermodynamics, the thermodynamic functions, equations of equilibrium, pressure-volume-temperature relations of fluids, thermodynamic properties and diagrams, compression and expansion of gases, heat effects of physical and chemical processes, refrigeration, heat engines, third law of thermodynamics, chemical equilibria, vaporization equilibria, vaporization processes.

The subject matter should be well illustrated by the assignment of numerical problems.

Suggested Texts:

There is no one textbook which adequately covers the various parts of thermodynamics in which the chemical engineer is interested. It will probably be desirable for the teacher

to use a combination of texts selected from the following list:

1. Ebaugh, N. C., *Engineering Thermodynamics.*
2. Faires, V. M., *Applied Thermodynamics.*
3. Hougen and Watson, *Industrial Chemical Calculations.*
4. Keenan, J. H., *Thermodynamics.*
5. Lewis and Randall, *Thermodynamics and the Free Energy of Chemical Substances.*
6. Weber, H. C., *Thermodynamics for Chemical Engineers.*

Unit Operations Laboratory II: AST-418

One seven-hour laboratory period and one conference hour for one term. This follows the same plan as the first laboratory, but the experiments would lie in the field of subjects covered in Unit Operations II.

Chemical Technology: AST-406

Prerequisite: General Chemistry, Analytical Chemistry, and Industrial Chemical Calculations.

The object of this course is to give a brief survey of the most important processes used in chemical industry from the standpoint of raw materials, economics, equipment and underlying physical and chemical principles. A typical list of subjects treated might include the following: Raw materials, water supplies, fuels, coal products, acids, alkalies, salts, explosives, chemicals used in warfare, fixed nitrogen, metallurgical processes, metals, control of chemical processes, plastics, rubber, petroleum products, synthetic organic chemicals, paints and varnishes and electrochemical industries.

The laboratory work would be largely confined to the testing and analysis of important industrial materials.

Typical Tests: Proximate analysis of coal, hardness of water, analysis of fuel and flue gases, viscosity and specific gravity of oils, distillation of gasoline, heat of combustion of coal or gas, boiler water tests, nitrogen in explosives, pH measurements, steel analysis, calibration of thermocouples. A laboratory properly equipped might include one or two experiments on chemical processes such as sulphonation, nitration, oxidation and the like.

Physical Metallurgy: AST-410

Prerequisite: Physical Chemistry.

Structure of metals and alloys interpreted by phase diagrams. The laboratory work consists chiefly in microscopical examination of specimens with an introduction to the preparation of specimens and of photomicrographs. Structure should be correlated with

physical properties, and it is desirable for students to be introduced to heat treating and mechanical testing apparatus.

Suggested Texts:

1. Desch, C. H., *Metallography.*
2. Williams and Homerberg, *Principles of Metallography.*

Chemical Engineering Problems: AST-420

Prerequisite: Unit Operations II.

The integration of material covered in Unit Operations, Chemical Technology, Physical Chemistry, Thermodynamics, Mechanics, et al., by solution of comprehensive problems. Experience is also to be gained in searching for the physico-chemical data required. An excellent list of typical problems is given by O. A. Hougen, "Comprehensive Problems in Chemical Engineering," pp. 323–40, in *Collected Papers on the Teaching of Chemical Engineering,* published by the American Institute of Chemical Engineers, 1940.

Suggested Texts:

1. Perry, *Chemical Engineers' Handbook.*

ARMY SPECIALIZED TRAINING PROGRAM

Advanced Phase

CIVIL ENGINEERING

CURRICULUM No. CE-1

Term 4	AST Nos.	Hrs. per wk.	Term 5	AST Nos.	Hrs. per wk.
Mathematics	401	5	Str. of Mat.	401	4
Mechanics	401	6	Mat. Test. Lab.	401	3
Surv. (Elem.)	407	6	Stress Anal.	413	5
Ele. of El. Engr.	401	8	Fluid Mech.	401	4
Eng. Dr.—Struct. Drafting	408	3	Sur.—Advanced	408	5
			Int. Comb. Eng.	405	6

Term 6	AST Nos.	Hrs. per wk.
Str. Design	403	7
Water Sup. & Sewerage	403	6
Trans.	403	6
Foundations	403	6
Eng. Dr.—Topo. Drafting	409	3

ARMY SPECIALIZED TRAINING PROGRAM

Mathematics: AST-401

For description see Mathematics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Mechanics: AST-401

For description see Mechanics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Surveying (Elementary): AST-407

Measurement of distance; measurement of differences in elevation; measurement of directions and angles; the stadia; traversing and making locations; laying out of buildings, sewers and other structures; methods of computation; coordinates and areas. Topographic surveying, field problems illustrative of classroom topics.

Suggested Texts:

1. Bouchard, *Surveying.*
2. Breed, *Surveying.*
3. Davis, *Elementary Plane Surveying.*
4. Rayner, *Elementary Surveying.*

Elements of Electrical Engineering: AST-401

For description see Elements of Electrical Engineering: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Engineering Drawing—Structural Drafting: AST-408

Drafting of timber and structural steel details, design and shop drawings, conventions and marking systems; erection diagrams, beam and column connections; roof and bridge truss details; plate girders. The emphasis on this course is to be placed on the development of the ability to read and use engineering drawings, and on the rapid production of legible structural drawings.

Suggested Texts:

1. French, *Engineering Drawing,* 5th Edition.
2. Giesecke, Mitchell, Spencer, *Technical Drawing.*
3. Schumann, *Technical Drafting.*
4. Svensen, *Machine Drawing.*

Strength of Materials: AST-401

For description see Strength of Materials: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Materials Testing Laboratory: AST-401

For description see Materials Testing Laboratory: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Stress Analysis: AST-413

Theory of Simple Structures. Reactions for fixed loads; algebraic and graphic determination. Stresses in simple trusses; fixed loads; algebraic resolution of forces, graphic diagram—Bow's method, algebraic method by sections—shears and moments. Determination of loads; dead load, live load, impact, wind loads, etc. Parallel chord bridge trusses; method of coefficients for dead and moving uniform live loads, influence diagrams, impact stresses and maximum combinations. Bridge trusses with inclined chords; method of sections by moments. Wind stresses; lateral systems, simple portals, approximate methods, stresses in a mill building frame. Beams and girders; shears and bending moments, shear and moment diagrams.

Suggested Texts:

1. L. E. Grinter, *Theory of Modern Steel Structures*, Vol. I.
2. Clyde T. Morris, *Simple Steel Structures.*
3. Shedd and Vawter, *Theory of Simple Structures.*
4. E. S. Sheiry, *Elements of Structural Engineering.*
5. Sutherland and Bowman, *Structural Theory.*

Fluid Mechanics: AST-401

For description see Fluid Mechanics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Surveying—Advanced: AST-408

Vertical and horizontal curves as related to railroads, highways and pipelines; measurement and computation of earthwork for construction operations; study of reconnaissance, preliminary and location surveys for rights of way; engineering astronomy; field problems illustrative of classroom topics, including topographic surveying and the determination of latitude and longitude.

Suggested Texts:

1. Bouchard, *Surveying.*
2. Breed, *Surveying.*
3. Davis, *Elementary Plane Surveying.*
4. Rayner, *Elementary Surveying.*

Internal Combustion Engines: AST-405

Principles of the design, construction and operation of internal combustion engines. Laboratory work to familiarize the students with the operation and adjustment of the internal combustion engine, and the calibration and use of instruments for measuring pressure, temperature, power, velocity, quantity of material, gas composition, etc. Simple tests on engines, centrifugal pumps, fans, and the like.

Suggested Texts:

1. Ensign and Lichty, *The Internal Combustion Engine.*
2. Taylor and Taylor, *The Internal Combustion Engine.*

Structural Design: AST-403

Elementary design of structures in wood, steel, and concrete. Principles of statically indeterminate analysis, deflection of beams, trusses, and analysis of indeterminate structures.

Suggested Texts:

1. Urquhart, O'Rourke, *Elementary Structural Analysis and Design.*

Water Supply and Sewerage: AST-403

Principles of the design, construction and operation of public water supply and sewerage systems. Water purification and treatment. Sewage treatment.

Suggested Texts:

1. Babbitt, *Sewerage and Sewage Disposal.*
2. Doland and Babbitt, *Water Supply Engineering.*
3. Hardenbergh, *Water Supply Engineering.*
4. Hardenbergh, *Sewerage and Sewage Disposal.*
5. Steel, *Water Supply and Sewerage.*
6. Waterman, *Water Supply Engineering.*

Transportation: AST-403

Elements of the design, construction and maintenance of highways, railways, and airways.

Foundations: AST-403

An introduction to the physical and mechanical properties of soil which govern its behavior as an engineering material. Piles

and pile foundations, spread footings, plain and reinforced; ordinary foundations; caissons; subaqueous foundations. Investigation of gravity retaining walls; counterforts; reinforced concrete walls.

Engineering Drawing—Topographic Drafting: AST-409

Principles of topographical drawings and map projections; methods of plotting; conventional symbols; representatives of relief by contours and the solution of problems related thereto; exercises in map making.

ARMY SPECIALIZED TRAINING PROGRAM

Advanced Phase

ELECTRICAL ENGINEERING

CURRICULUM No. EE-1

Term 4	AST Nos.	Hrs. per wk.	Term 5	AST Nos.	Hrs. per wk.
Mathematics	401	5	El. Circuits	414	11
Mechanics	401	6	Eng. Math.	403	3
El. Meas.	403	6	Str. of Mat.	401	4
El. & Mag. Ph.	405	8	Mat. Tes. Lab.	401	3
Shop Pract.	406A	3	Dir. Cur. Mach.	409	6

Term 6	AST Nos.	Hrs. per wk.	Term 7	AST Nos.	Hrs. per wk.
(Communications Specialists)					
El. & Ass. Cir., Theory & Lab.	415	11	High Fre. & U. H. F. Cir. & Lab.	420	12
El. Cir.—Tran.	416	5	Com. Networks	422	6
El. Cir.—Dis. Con.	417	3	Servo-Mech. & Con. Devices	424	6
Al. Cur. Mach.	410	8	Rad. & Prop.	426	3
(Power Specialists)					
A.C. Mach.	411	7	A.C. Mach.	412	9
El. & Ass. Cir.	415	10	Servo-Mech. & Con. Devices	424	6
El. Cir.—Tran.	416	5	Int. Com. Eng.	410	6
Thermodynamics	401	5	Int. Com. Eng. Lab.	411	4
			El. Power Tran.	412	3

ARMY SPECIALIZED TRAINING PROGRAM

Mathematics: AST-401

For description see Mathematics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Mechanics: AST-401

For description see Mechanics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Electrical Measurements: AST-403

A laboratory course. Introduction to the use of electrical measuring instruments and methods. Laboratory technique, including set-up of equipment and use of hand tools for assembly and wiring of laboratory devices. Measurement of electric and magnetic circuit quantities.

Suggested Texts:

1. Laws, *Electrical Measurements.*

Electric and Magnetic Phenomena: AST-405

Establishment of basic concepts of electrical engineering, and definition of quantities used. The electric circuit, component parts, relations. The magnetic circuit. Properties of magnetic materials. The magnetic field. Generated voltages. Forces on conductors. Solutions of simple circuit problems.

Suggested Texts:

1. Attwood, *Electric and Magnetic Fields.*
2. Bennett and Crothers, *Introductory Electrodynamics for Engineers.*
3. Strong, *Electrical Engineering, Basic Analysis.*
4. Timbie and Bush, *Principles of Electrical Engineering.*

Shop Practices: AST-406A

Classification, use, and maintenance of tools; measuring and gaging; wood working; metal working; electric soldering iron practice; soldering splices, cords, plugs, and radio equipment; torch soldering and welding practice. Lectures, movies, and demonstrations of basic manufacturing methods.

Note: See Shop Practices AST-406 which covers more material than AST-406A. Requirements for AST-406A may be met by a choice of elements from AST-406.

Electric Circuits (D.C. and A.C.): AST-414

A study of the principles of electric circuit theory. Kirchhoff's Laws and network theorems applied to d.c. circuits. Alternating current quantities. Effective values. Exponential and complex numbers applied to alternating current quantities. Alternating-current circuits. Kirchhoff's laws applied to alternating current circuits. Single-phase and polyphase circuits. Power and energy measurement. Network theorems. Non-sinusoidal waves of voltage and current. Fourier series. Harmonic analysis.

Suggested Texts:

Texts for D.C. circuits included in "Electric and Magnetic Phenomena AST-405" or "D.C. Machinery AST-409."

1. Kerchner and Corcoran, *Alternating Current Circuits.*
2. Tang, *Alternating Current Circuits.*

Engineering Mathematics: AST-403

This course is to include those topics peculiar to engineering problems not covered in Mathematics AST-401, and a more exhaustive study of topics previously covered.

Strength of Materials: AST-401

For description see Strength of Materials: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Materials Testing Laboratory: AST-401

For description see Materials Testing Laboratory: AST-401 in Mechanical Engineering Curriculum No. ME-1.

Direct Current Machinery: AST-409

A study of direct current machines. Construction. Operation. Characteristics and Applications.

Suggested Texts:

1. Kloeffler, Brenneman, and Kerchner, *Direct Current Machinery.*
2. Langsdorf, *Principles of D.C. Machines.*

Laboratory:

A laboratory study of the characteristics of direct current machinery.

Electronics and Associated Circuits, Theory and Lab.: AST-415

Fundamentals of Electronics and application to communication circuits. Principles of operation of electronic devices. Analysis of behavior of electronic devices in circuits. Audio-frequency amplifiers. Radio-frequency amplifiers. Feedback. Oscillators. Modulation and demodulation.

Suggested Texts:

1. Dow, *Engineering Electronics* (parts of).
2. Millman and Seely, *Electronics* (parts of).
3. Reich, *Theory and Application of Electron Tubes* (parts of).
4. Terman, *Radio Engineering.*

Laboratory:

Laboratory study of electronic devices and associated circuits. Characteristics of vacuum and gas-filled tubes. Properties of circuit elements at high frequencies. Amplifier circuits. Power supplies. Oscillations. Modulators and demodulators.

Suggested Texts:

1. Terman, *Measurements in Radio Engineering.*

Electric Circuits—Transients: AST-416

A study of the electric circuit with special emphasis on the transient state. Transients in d.c. and a.c. circuits. Non-linear circuits.

Suggested Texts:

1. Guillemin, *Communication Networks,* Vol. I.
2. Kurtz and Corcoran, *Introduction to Electric Transients.*
3. Skilling, *Transient Electric Currents.*

Electric Circuits—Distributed Constants: AST-417

A study of the electric circuit with distributed parameters. Voltage and current distribution in the steady state. Characteristics of open and coaxial lines. Use of line as a circuit element. Use of line as a measuring device. Loading. Impedance matching and stubbing.

Suggested Texts:

1. Everitt, *Communication Engineering.*
2. Ware and Reed, *Communication Circuits.*

Alternating Current Machinery: AST-410

A study of alternating current machinery. Construction. Operation. Characteristics and applications. Emphasis on transformers and induction machinery. Selsyn devices.

Suggested Texts:

1. Dawes, *Electrical Engineering.*
2. Hehre and Harness, *Electric Circuits and Machinery*, Vol. II.

Laboratory:

A laboratory study of the characteristics of A.C. machinery.

High Frequency and Ultra High Frequency Circuits: AST-420

A continuation of the electronics and high frequency circuit course, and an extension into the ultra high frequency field. Special devices used in the generation of u.h.f. Behavior of circuits at u.h.f. Radiation and antenna arrays. Wave guides. Horns and parabolas.

Suggested Texts:

1. Brainerd and others, *Ultra-high-frequency Techniques.*
2. Reich, *Theory and Application of Electron Tubes.*
3. Terman, *Radio Engineering.*

Laboratory:

A continuation of the electronics and high frequency laboratory with special emphasis on ultra high frequency techniques.

Communication Networks: AST-422

Properties and synthesis of transmission networks and filters. General properties of networks. Propagation and impedance functions. Networks as a wave filter. Derived type of filter. Composite filters. Corrective networks. Generalized filter theory and network synthesis.

Suggested Texts:

1. Guillemin, *Communication Networks*, Vols. I and II.
2. Shea, *Transmission Networks and Wave Filters.*

Servo-Mechanisms and Control Devices: AST-424

General treatment of automatic control devices, including mechanical and electronic relays, thrustors, selsyn motors, amplidynes, and similar types of machines.

Suggested Texts:

Current literature, manufacturers' instruction bulletins, and lecture notes.

Radiation and Propagation: AST-426

Electromagnetic waves, current and voltage distribution on antennas, electromagnetic radiation, field distribution, directional antennas, propagation of electric waves, ionosphere, ground wave, sky wave, direct wave, fading characteristics.

A.C. Machinery: AST-411

An intensive study of the theory of construction and characteristics of Alternators, Synchronous Motors, and Transformers. Special attention will be given to the fundamental concepts of magnetomotive forces and leakage reactances which control the characteristics of the machine.

Note: See A.C. Machinery: AST-412 in 7th term for continuation of this course.

Suggested Texts:

1. Bryant, *A.C. Machinery.*
2. Lawrence, *A.C. Machinery.*
3. Langsdorf, *A.C. Machinery.*
4. Richstein and Loyd, *A.C. Machinery.*

Thermodynamics: AST-401

For description see Thermodynamics: AST-401 in Mechanical Engineering Curriculum No. ME-1.

A.C. Machinery: AST-412

A continuation of AST-411 covering polyphase and single phase induction motors, synchronous convertors, polyphase rectifiers, and variable speed alternating current motors.

Note: See A.C. Machinery: AST-411 in 6th term for preliminary course.

Suggested Texts:

Same as A.C. Machinery: AST-411.

Internal Combustion Engines: AST-410

For description see Internal Combustion Engines: AST-410 in Mechanical Engineering Curriculum No. ME-1.

Internal Combustion Engines Laboratory: AST-411

For description see Internal Combustion Engines Laboratory: AST-411 in Mechanical Engineering Curriculum No. ME-1.

Electric Power Transmission: AST-412

A study of the electrically long power circuit. Current and voltage distribution. Power flow and power limits. Introduction to stability. Voltage regulation and adjustment.

Suggested Texts:

1. Loew, *Electrical Power Transmission.*
2. Woodruff, *Electric Power Transmission.*

ARMY SPECIALIZED TRAINING PROGRAM

Advanced Phase

MECHANICAL ENGINEERING

CURRICULUM No. ME-1

Term –	AST Nos.	Hrs. per wk.	Term –	AST Nos.	Hrs. per wk.
Mathematics	401	5	Str. of Mat.	401	4
Mechanics	401	6	Mat. Test. Lab.	401	3
Thermo.	401	5	Int. Com. Eng.	410	6
Engr. Draw.	406	4	Mech. Lab.	420	3
Shop Pract.	406	6	Kinematics	402	6
			Met. & Heat Treat.	430	4

Term –	AST Nos.	Hrs. per wk.
Mech. Vib.	410	3
Mach. Design	408	9
Fluid Mech.	401	4
Int. Com. Eng., Lab.	411	4
Ele. of El. Engr.	401	8

ARMY SPECIALIZED TRAINING PROGRAM

Mathematics: AST-401

Prerequisite: Differential Calculus.

Formal integration completed with further application, including pressure and work. Radius of Curvature. Curvilinear Motion.

Infinite Series: (*a*) Convergence and Divergence, (*b*) Maclaurin and Taylor Series, (*c*) Applications to Computation. Partial Differentiation with applications. Double and triple integration. Centers of gravity. Moments of inertia. Differential equations: (*a*) Linear of first order, (*b*) Second order with constant coefficients; particular integral to be found by method of undetermined coefficients. In differential equations, as throughout the whole work in calculus, emphasis is to be placed on applications to physical problems.

Suggested Texts:

1. Granville, Smith, and Longley, *Differential and Integral Calculus.*
2. Love, *Differential and Integral Calculus.*
3. Miller, *Calculus.*
4. Sherwood and Taylor, *Calculus.*

Mechanics: AST-401

Statics: Scalers and vectors; resolution and composition of forces; moment of forces; couples; resultants of force systems, algebraically and graphically; equilibrium of force systems, algebraically and graphically; bridge trusses. Friction: laws and applications. First and second moments.

Dynamics: Linear and angular displacements, velocities and accelerations of particles and rigid bodies, motion of projectiles; relative motion; Newton's Laws as applied to bodies in translation, rotation and plane motion. Work-kinetic energy relationship for bodies in translation, rotation, and plane motion. Power and efficiency of machines. Impulse-momentum relationships of bodies in translation, rotation and plane motion. Conservation of momentum.

Suggested Texts:

1. Boyd, *Mechanics.*
2. Brown, *Engineering Mechanics.*
3. Fairman and Cutshall, *Engineering Mechanics.*
4. Maurer and Roark, *Technical Mechanics.*
5. Poorman, *Applied Mechanics.*
6. Seely and Ensign, *Analytical Mechanics for Engineers.*

Thermodynamics: AST-401

The object of this course is especially to prepare the students for the study of the internal combustion engine and the gas turbine. The theoretical topics are mentioned. The order in which topics are mentioned is not intended to be the order of their presentation.

Each teacher will prefer his own time table. Some of the topics must obviously be treated briefly.

Gas laws. The ideal gas equation of state. The gas constant, universal and individual. The pressure-volume, temperature-volume, and pressure-temperature diagrams.

Energy and the energy law. Heat and work. Specific heats and their ratio and difference. Adiabatic processes. Polytropic processes. Air compression and the compressed air engine.

The Carnot cycle, as the standard of excellence, as the basis of the absolute scale of temperature, and as the index of ideal availability. Entropy and unavailability. The temperature-entropy diagram. Reversibility. The heat pump.

The Brayton, Otto, and Diesel cycles, with brief mention of their execution in internal combustion engines and the gas turbine.

Steady flow processes and equations (energy and continuity). The enthalpy-entropy and enthalpy-volume diagrams. Nozzles for metering, for the jet pump, and for the turbine.

Liquids and vapors. Two-phase states. Steam tables and charts. Steam power. Vapor refrigeration.

Mixtures of gases and of gas vapor. Dalton's law of partial pressures. Gas analysis. Atmospheric humidity. Psychrometric chart. Air conditioning.

Suggested Texts:

1. Barnard, Ellenwood, and Hirshfeld, *Elements of Heat-Power Engineering.*
2. Ellenwood and Mackey, *Vapor Charts.* Gives charts for steam, liquid water, ammonia, Freon 12, psychrometric chart, and tables for barometer correction, for jet velocity, and squares of numbers.
3. Faires, V. M., *Applied Thermodynamics.*
4. Keenan and Keyes, *Thermodynamic Properties of Steam.*
5. Kiefer and Stuart, *Principles of Engineering Thermodynamics.*
6. Marks, Lionel S., *Mechanical Engineers' Handbook*, Fourth Edition, Sections 4, 7, 9, 14, 16.
7. Young and Young, *Elementary Engineering Thermodynamics.*

Engineering Drawing: AST-406

Detail and assembly drawings: Simple mechanisms and machines —representation, idioms, conventions, specifications and reading. Empirical drawings and charts. Jigs and Fixtures (basic principles).

Suggested Texts:

1. French, *Engineering Drawing.*
2. Giesecke, Mitchell, Spencer, *Technical Drawing.*

3. Jordan and Hoelscher, *Engineering Drawing.*
4. Meadowcroft, *Aircraft Detailed Drafting.*
5. Schumann, *Technical Drafting.*
6. Svensen, *Machine Drawing.*

Shop Practices: AST-406

Objective: This laboratory course in shop theory and practice is intended not to produce manual skill but to acquaint the student with the principles of operation, capabilities, and limitations of the machine tools; and processes used in the construction, maintenance, and repair of mechanical equipment in order that he may be better qualified to supervise the maintenance and repair of military equipment in the field.

The course content should include: (1) theory and practice of welding by gas and electric arc; limitations and applications to construction repair; (2) forging and heat treating of small parts; (3) hand tools and bench work including use of the hammer, file, chisel, taps, and dies; (4) sheet metal layout, cutting and forming; (5) theory and operation of machine tools. Lathes, milling, machines, shapers and planers, grinders; (6) measurement and measuring instruments such as scales, calipers, gages, micrometers, verniers.

Suggested Texts:

No textbook is suggested. The course should be taught by the lecture-demonstration method with an opportunity for each student actually to do the operations. Excellent training films are available from the United States Office of Education and from the Signal Corps of the United States Army. Schools having inadequate laboratory facilities should make extensive use of such films.

Strength of Materials: AST-401

Stresses and strains in tension, compression and shear—riveted and welded joints—shear and moment in beams—design of simple, cantilever and continuous beams for strength and stiffness—beams of two or more materials—resilience of beams—combined flexural, tensile, compressive, and shearing stresses. Design of columns.

Suggested Texts:

1. Boyd, *Strength of Materials.*
2. Laurson, Cox, *Mechanics of Materials.*
3. Maurer, Withey, *Strength of Materials.*
4. Poorman, *Strength of Materials.*

5. Seely, *Resistance of Materials.*
6. Timoshenko, *Strength of Materials.*

Materials Testing Laboratory: AST-401

The course is designed to study in the laboratory, by means of tests, engineering materials as related to their use in machinery and military equipment. Recognized methods of testing, as used in inspection of ordnance materials, should be followed. Students should become familiar with such methods as are described in Federal Specifications QQ-M-151a for metals, A.S.T.H. Specifications, etc.

Problems suggested for inclusion are:

1. Study of hydraulic and lever-type testing machines, including calibration.
2. Strain measuring gages of several types.
3. Tests of steel in tension for such properties as: proportional limit, yield point, yield strength, stiffness, ductility.
4. Acceptance type test of metals in tension.
5. Flexure test of ductile metal.
6. Torsional shear of metal.
7. Hardness: Rockwell, Brinell, Scleroscope.
8. Compression of short and long columns.
9. Impact: Izod, Charpy.
10. Flexure of wood beams.
11. Welded joints.
12. Helical springs.

Suggested Texts:

1. American Society for Testing Materials, *Selected Standards for Students in Engineering.*
2. Davis, Troxell, Wiskocil, *Testing and Inspection of Engineering Materials.*
3. Gilkey, Murphy, Bergman, *Materials Testing.*
4. Superintendent of Documents, Washington, D. C., *Federal Specifications, QQ-M-151a, Metals, General Specifications for Inspection of.*

Internal Combustion Engines: AST-410

Fuels and combustion: petroleum products and properties; combustion mixture requirements; explosive limits. Heat transfer by radiation, conduction and convection. Spark ignition engine: Otto cycle; standard air cycle; fuel-air cycle; carburetion (float and pressurized); combustion and flame travel. Detonation and detonation suppressors; heat transfer; valve gear and valve timing;

ignition systems and spark timing; gear and turbo supercharging of aircraft engines; engine performance characteristics. Compression ignition engine; diesel cycle; fuel injection systems; combustion and combustion chambers; diesel knock; injection timing; diesel supercharging; engine performance characteristics. Gas turbines: gas turbine cycles, closed and open; heat exchangers; fuels and combustion chambers; temperature and pressure limitations; effect on efficiency of turbine, compressor and heat exchanger performance.

Suggested Texts:

1. Lichty, *The Internal Combustion Engine.*
2. Taylor and Taylor, *The Internal Combustion Engine.*

Mechanical Laboratory: AST-420

The object of this course is to familiarize the student with the instruments and techniques used in studying the performance of mechanical equipment, and to acquaint the student with the principles of operation and with the performance of such equipment through direct contact. Calibration and use of instruments for measuring pressure, temperature, power, velocity, quantity of material, gas composition, etc. Simple tests on engines, centrifugal pumps, fans, and the like. A.S.M.E. Power Test Codes for various machines and chapters on Instruments and Apparatus should be helpful.

Kinematics: AST-402

Composition and resolution of vectors; relation between linear and angular displacement; velocities; accelerated rectilinear motion; tangential and normal acceleration; relative motion. Transmission of motion; kinematic chains; nature of rolling and sliding; conditions for pure rolling; positive driving. Analysis of plane motion; linear and angular velocities; velocity and acceleration graphs. Cams; displacement, velocity and acceleration graphs. Rolling curves and friction gearing. Straight and helical spur gears; terminology; forms of teeth; interchangeability; interference of involute teeth; specific sliding and velocity of sliding; selection of cutters; strength, wear and noise of gear teeth; internal involute gears. Methods of cutting and generating straight and helical spur gears. Straight and spiral bevel gears. Helical and hyperboloidal gears. Worm and worm wheel. Linkwork and miscellaneous mechanisms; four-link; slider crank; quick return; straight line; pantographs; Hooke's coupling; ratchets and escapements. Belt, rope and chain transmission; belt tension and power; length of belt; cone pulleys; speed cones; V-belt drives; rope drives; transmission chains. Trains of mechanism: sliding gears; clutches; idler gears; reversing mecha-

nisms; change gear mechanism; wheel trains; cyclic trains; reverted cyclic trains.

Suggested Texts:

1. Alvert, Rogers, *Kinematics of Machinery.*
2. Guillet, *Kinematics of Machines.*
3. Heck, *Mechanics of Machinery.*
4. Keown and Faires, *Mechanism.*
5. Schwamb, Merrill, James, *Elements of Mechanism.*

Metallography and Heat Treatment: AST-430

The objective of this course is to familiarize the student with metals, their properties, heat treatment, limitations and correct application, and to provide him with a background of information necessary for inspection work and for the supervision of the repair and maintenance of military equipment. Fundamentals of heat treatment: pure metals, solidification, hot and cold working, annealing, alloy formation and alloy systems. Bearing alloys. Light alloys: aluminum and magnesium base. Copper alloys: brasses, bronzes, etc. Carbon steels: carbon free iron, iron-carbon alloys, impurities, classification of steels, heat treatment, hardening. Low and medium alloy steels: composition, structure, heat treatment, applications. Surface treatment of steels: surface hardening, hard surfacing, protective coatings. Steel castings: composition, heat treatment, applications. Welding. Brazing and soldering. Cast irons: composition, structure, properties and applications. Heat and corrosion resistant steels. Wear resistant steels. Tool steels. Machinability.

Suggested Texts:

1. Heyer, R. H., *Engineering Physical Metallurgy.*
2. Sisco, F. T., *Modern Metallurgy for Engineers.*

Supplementary Text Material:

- a. Aluminum Company, *Alcoa Aluminum and Its Alloys.*
- b. Aluminum Company, *Aluminum in Aircraft.*
- c. Aluminum Company, *Machining Aluminum.*
- d. Aluminum Company, *Welding Aluminum.*
- e. Aluminum Company, *Finishes for Aluminum.*
- f. Chase Brass & Copper Company, *Commercially Important Wrought Copper Alloys.*
- g. Dow Chemical Company, *Dowmetal Magnesium Alloys.*
- h. Revere Copper Company, *Revere Copper and Copper Alloys.*
- i. Mimeographed Material on NE Steel Pamphlets, Prepared by Department.

Mechanical Vibrations: AST-410

Kinematics of vibration, harmonic and non-harmonic; systems of single, two, and many degrees of freedom; free and forced vibrations, with and without damping, applications, slider crank mechanisms, rotative machinery, balancing. Self-excited vibrations, non-linear characteristics, vibration measuring instruments, balancing machines.

Machine Design: AST-408

Stresses in machine parts; properties of materials; screw fastenings; keys, small pins and cotters; systems of fits with tolerances and allowances; welded joints; springs; bearings and their lubrication; brakes; screws for power transmission; shafts; couplings; belt drive; chain drive; crank shafts; flywheels; friction gearing; toothed gearing; machine frames.

Suggested Texts:

1. Albert, *Machine Design Drawing Room Problems.*
2. Bradford and Eaton, *Machine Design.*
3. Hyland and Kommers, *Machine Design.*
4. Kimball, Barr, *Elements of Machine Design.*
5. Leutwiler, *Elements of Machine Design.*
6. Maleev, *Machine Design.*
7. Vallence, *Design of Machine Members.*

Fluid Mechanics: AST-401

Physical properties of common fluids such as density, viscosity, compressibility; fluid statics—pressure forces on submerged bodies, pressure gages, flotation; general study flow relations—streamlines, continuity equation, energy equation, flow meters; dynamic lift, magnus effect, deflecting forces on projectiles, flow of incompressible and compressible fluids in pipes and around bodies such as air foils; laminar and turbulent flow; elementary exterior ballistics; types of flow above and below the velocity of sound; shock waves, resistance of projectiles, compressibility effects on a bullet in flight; elementary acoustics, sound propagation, magnitude of velocity of sound, sound detectors, sound ranging; construction, operation and performance of pumps, fluid couplings, torque converters, pressure intensifiers, hydraulic control systems for operating shock absorbers, gun turrets, recoil mechanisms, retractable landing gears and numerous other military applications.

Suggested Texts:

1. Dodge, R. A., and M. J. Thompson, *Fluid Mechanics.*
2. Drysdale, C. V., A. Ferguson and others, *The Mechanical Properties of Fluids.*

3. Jameson, A. H., *An Introduction to Fluid Mechanics.*
4. Murphy, G., *Mechanics of Fluids.*
5. O'Brien, M. P., and G. H. Hickox, *Applied Fluid Mechanics.*
6. Vennard, J. K., *Elementary Fluid Mechanics.*

Internal Combustion Engines Laboratory: AST-411

The object of this course is to give the students familiarity with the operation and adjustment of the internal combustion engine, and to show them the influence of various operating conditions. Performance tests of spark ignition and diesel engines on dynamometer. Effects on capacity and efficiency of speed, throttle opening, fuel-air mixture. Fuel rating by C.F.R. engine.

Elements of Electrical Engineering: AST-401

The study of conductor materials in the form of wires of circular or rectangular cross section from the standpoint of resistance, wire tables, and allowable current capacity as prescribed by the Underwriters Laboratory. Use of ammeters, voltmeters, wattmeters and associated equipment to measure current, voltage and power in either DC or AC circuits. Circuits and connections of various types of generators such as separately excited, self excited and compound DC generators; single phase and polyphase AC generators with trouble shooting hints and specific applications of each type. Circuits, connections and operating characteristics of motors such as shunt, series and compound DC motors; AC single phase repulsion, repulsion start induction run, capacitor, shaded pole and split phase types; three phase squirrel cage, double squirrel cage, wound rotor and synchronous motors with trouble shooting hints and specific applications of each type with the starting equipment necessary. Connection and operation of transformers when connected single phase and polyphase star, delta and open delta.

Laboratory:

The laboratory will cover the material as outlined above.

Suggested Texts:

1. Blalock, *Principles of Electrical Engineering.*
2. Cook, *Elements of Electrical Engineering.*
3. Dawes, Chester L., *Industrial Electricity*, Parts 1 and 2.
4. Gray and Wallace, *Principles and Practice of Electrical Engineering.*
5. Hausmann, Erich, *Swope's Lessons in Practical Electricity.*
6. Kerchner and Corcoran, *Alternating Current Circuits.*
7. Loew, *Direct and Alternating Currents.*
8. Tang, *Alternating Current Circuits.*

ARMY SPECIALIZED TRAINING PROGRAM

Advanced Phase

Curriculum No. SE1

SANITARY ENGINEERING

Prerequisite

The course in Sanitary Engineering (Terms 7, 8) is predicated on the successful completion of the Army Specialized Training Program Advanced Phase Curriculum No. CE1, Civil Engineering (Terms 4, 5, 6), or its equivalent. Equivalency can be determined as follows:

1. Testing of selected applicants or applicants who had partially completed a college course in engineering.
2. A selected applicant or applicant holding a degree in Civil Engineering from an accredited college.

7th Term

Subject	Total Contact Hours per week*	Recommended Distribution Class	Lab.
Sanitary Chemistry: AST-245	9	3	6
Sanitary Bacteriology: AST-960	9	3	6
Hydrology: AST-962	3	3	0
Parasitology: AST-961	6	2	4
Drainage: AST-963	3	3	0
Total	30	14	16

8th Term

Subject	Total Contact Hours per week*	Recommended Distribution Class	Lab.
Sanitary Conference: AST-968	4	4	0
Water Treatment: AST-964	9	3	6
Sewage Treatment and Disposal: AST-965	9	3	6
Sanitation: AST-967	4	4	0
Epidemiology: AST-966	3	3	0
Total	29	17	12

* Required by contract.

Sanitary Chemistry: AST-245

Elementary organic chemistry; chemical methods for the examination of water and sewage; applications of principles for the control of water purification and sewage treatment plants.

Suggested Texts:

1. Adkins, McElhain, *Elements of Organic Chemistry.*
2. Theroux, Eldrige, Mallman, *Analysis of Water and Sewage.*

Sanitary Bacteriology: AST-960

Elementary bacteriology with emphasis placed on the roles of bacteria in public health; bacteriological methods used in the examination of water and the control of water treatment plants.

Suggested Texts:

1. Prescott, Winslow, *Elements of Water Bacteriology.*
2. Tanner, *Practical Bacteriology.*

Hydrology: AST-962

Occurrence and distribution of water by natural processes. Analysis of climatological and stream flow data. Storage problems.

Suggested Texts:

1. Mead, *Hydrology.*
2. Meyer, *Elements of Hydrology.*

Parasitology: AST-961

Fundamental principles involved in the control of belminthes, protozoa, insects, and rodents related to human welfare.

Suggested Texts:

1. A.A.A.S. Science Press, *Symposium on Human Malaria.*
2. Belding, *Clinical Parasitology.*
3. Craig, *Laboratory Diagnosis of Protozoan Diseases.*
4. Pearson, *Sanitary Entomology.*

Drainage: AST-963

Fundamental principles of land drainage with particular reference to mosquito control by drainage.

Suggested Texts:

1. Pickles, *Drainage and Flood-Control Engineering.*

Sanitary Conference: AST-968

Seminar on assigned readings and field trips. Emphasis will be placed on sanitation problems peculiar to tropical climates.

Suggested Texts:

Reference library.

Water Treatment: AST-964

Study of methods and processes used for the production of safe, portable water for human consumption.

Suggested Texts:

1. Manual Am. Soc. C.E., *Water Treatment Plant Design.*
2. Manual A.W.W.A., *Water Quality and Treatment.*

Sewage Treatment and Disposal: AST-965

Fundamental principles involved in the treatment and disposal of human excreta.

Suggested Texts:

1. Babbitt, *Sewerage and Sewage Treatment.*
2. Imhoff and Fair, *Sewage Treatment.*

Sanitation: AST-967

Fundamental principles involved in the elimination and control of sanitary hazards in the environment with particular emphasis on problems involving mosquitoes, flies, refuse disposal, and plumbing.

Suggested Texts:

1. Dunham, *Military Preventive Medicine.*
2. Ehlers and Steel, *Municipal and Rural Sanitation.*
3. Hardenbergh, *Mosquito Eradication.*

Epidemiology: AST-966

The more common communicable diseases: methods and problems involved in epidemiological investigations.

Suggested Texts:

1. Dunham, *Military Preventive Medicine.*

THE NAVY COLLEGE TRAINING PROGRAM

By IVAN C. CRAWFORD

Dean, College of Engineering, University of Michigan

The objective of the Navy College Training Program, V-12, is "to prepare officer material for the various branches of the Naval, Marine, and Coast Guard services, including aviation cadets, engineer and deck officers, engineer specialists, medical and dental officers, Supply Corps officers." This objective is to be accomplished by (1) choosing the best qualified young men available, and (2) sending these candidates to selected colleges and universities for training.

The following notes cover the general program. Only the curricula schedules of the engineering division of the program are shown.

Selection of Students

Students from civilian life are to be selected by a process which includes: (1) the passing of a qualifying test designed by the Navy Department and administered at local or nearby schools or colleges; (2) interviews at the nearest office of Naval Officer Procurement "to determine potential officer-like qualities," and a physical examination; and (3) review of records by a selection committee composed of an educator, a representative civilian, and a Naval officer. The decision of this committee will be final.

Properly qualified enlisted men now on duty in the Navy may enter the program upon approval of applications by their commanding officers and the passing of the general classification test or a comparable test designated by the Bureau of Naval Personnel.

Lengths of Training Periods

Sixteen weeks is the length of the term in this program. Aviation candidates remain in college for two terms; deck candidates, four terms; engineer candidates, general, six terms; and engineer specialist candidates, eight terms or 128 weeks.

For the last group, engineer specialist candidates, the length of the college course rather closely approximates the normal time re-

quired for a degree. It should be noted that these students, and all students in the program, will be required to spend 52 to 58 hours per week in class, laboratory, and preparation.

The term starting dates will be on or about July 1, November 1, 1943, and March 1, 1944.

Course Descriptions

The courses of the program have been molded so as to conform rather closely to those which are standard in the engineering colleges of the nation. In a few cases, departures have been made from the standard where the interests of the Navy demanded the inclusion of new matter or the exclusion of subject matter not closely related to the program. The course descriptions conform to the usual college style of writing such descriptions, although in general they are somewhat more detailed. It is expected that institutions will expand and amplify the minimum outlines presented within the scope of their facilities and the time limits imposed. All descriptions were written with the aid of specialists in the fields covered.

The titles appearing in the following curricula schedules indicate in a general way the subject matter contained in the course. However, the Structures series in the Civil Engineer Corps curricula require some explanation. Structures I is Structural Analysis; Structures II, Theory of Reinforced Concrete; Structures III, Elementary Structural Design in Steel and Wood; Structures IV, Concrete Structures and Foundations; and Structures V, Advanced Structural Steel Design. Electrical Engineering I and II are the courses in this subject usually offered to non-electrical engineering students.

Students who have previously completed courses of the prescribed curricula and who can demonstrate this to the satisfaction of the institution they are attending will be permitted to make proper substitutions in their programs.

Examinations, Texts, Credits

Each institution taking part in the program will set examinations for the various courses offered according to its own practices. In this connection, it should be noted that near the end of the second term of the first college year, the Navy Department will give a qualifying examination to all students.

The selection of textbooks is left to the college, with the provision that those adopted must be generally recognized as standard.

Each institution will determine whether or not credit toward a degree shall be given for the completion of courses in the various curricula. Inasmuch as the content of these courses is practically equivalent to that of standard college courses in the same subjects, it is expected that credit will be given quite generally.

Extra-Curricular Activities

Students of the V-12 program will be permitted to participate in extra-curricular activities the same as civilian students in so far as this participation does not interfere with prescribed hours or courses of study. These students will also be permitted to take part in all college athletics on the same basis as civilian students within the limits noted above.

Students in the program will be allowed to join all previously established organizations or fraternities on the campus which are available to all students on the same terms. They will not be permitted to establish or join any activity or organization in which membership is not available to all students, civilian or enlisted, on the campus, or which might be inimical to Naval interests.

The Navy College Training Program has been developed in the Training Division of the Bureau of Naval Personnel with the cooperation of the several bureaus of the Navy Department and of a number of civilian consultants, among them the writer.

THE NAVY COLLEGE TRAINING PROGRAM

First College Year

The curriculum is designed for the following types of officer candidates:

A-V(N) Aviation Candidates.
CEC-V(S) Civil Engineer Corps Candidates.
CC-V(S) Construction Corps Candidates.
D-V(G), D-V(S), C-V(S) Deck Candidates.
E-V(G) Engineer Candidates.
E-V(S), O-V(S), A-V(S) Engineer Specialist Candidates.
(*a*) Mechanical, Steam Engines.
(*b*) Mechanical, Internal-Combustion Engines.
(*c*) Electric, Power.
(*d*) Electric, Communication.

	Periods per week†	
	1st term	*2nd term*
Mathematical Analysis I or III, II or IV	*5 (5)	*5 (5)
English I-II	3 (3)	3 (3)
Historical Background of Present World War. I-II	2 (2)	2 (2)
Physics I, II	4 (6)	4 (6)
Engineering Drawing and Descriptive Geometry	2 (6)	2 (6)
Naval Organization I, II	1 (1)	1 (1)
	17 (23)	17 (23)
Physical Training	2 (6)	2 (6)
	19 (29)	19 (29)

Second College Year

Curriculum I. *CEC-V(S). Civil Engineer Corps Candidates.*

Calculus I, II	4 (4)	4 (4)
Chemistry Ia-IIa and Engineering Materials	4 (6)	4 (6)
Analytical Mechanics I, II		5 (5)
Surveying—Plane and Geodetic	3 (7)	5 (11)
Naval History and Elementary Strategy	3 (3)	
Psychology I—General	3 (3)	
	17 (23)	18 (26)
Physical Training	2 (6)	2 (6)
	19 (29)	20 (32)

* Mathematical Analysis I, II—combination course in mathematical analysis for students entering with 2 or less units of mathematics. Mathematical Analysis III, IV—algebra, trigonometry, and analytical geometry; or analytical geometry and calculus for students entering with 2½ or more units of mathematics.

† *Note:* Figures in parenthesis indicate *contact hours* per week in class and laboratory. Figures outside of parenthesis indicate the number of *meetings* per week in class and laboratory.

	Periods per week* 1st term	Periods per week* 2nd term
CURRICULUM II. *CC-V(S). Construction Corps Candidates.*		
Calculus I, II	4 (4)	4 (4)
Chemistry Ia-IIa, and Engineering Materials	4 (6)	4 (6)
Analytical Mechanics I, II		5 (5)
Economics I-II, Principles of	3 (3)	3 (3)
Naval History and Elementary Strategy	3 (3)	
Kinematics		2 (4)
Psychology I—General	3 (3)	
	17 (19)	18 (22)
Physical Training	2 (6)	2 (6)
	19 (25)	20 (28)
CURRICULUM III. *D-V(G), D-V(S), C-V(S). Deck Candidates.*		
Navigation and Nautical Astronomy I, II	3 (3)	3 (3)
Chemistry Ia-IIa, and Engineering Materials	4 (6)	4 (6)
Elementary Heat Power	3 (5)	
Electrical Engineering (A)—Elementary		3 (5)
Calculus I, II, and Analytical Mechanics I	5 (5)	5 (5)
Naval History and Elementary Strategy	3 (3)	
Psychology I—General		3 (3)
	18 (22)	18 (22)
Physical Training	2 (6)	2 (6)
	20 (28)	20 (28)
CURRICULUM IV. *E-V(G). Engineer Candidates.*		
Calculus I, II	5 (5)	3 (3)
Navigation and Nautical Astronomy I, II	3 (3)	3 (3)
Chemistry Ia-IIa, and Engineering Materials	4 (6)	4 (6)
Naval History and Elementary Strategy	3 (3)	
Analytical Mechanics I, II		5 (5)
Psychology I—General	3 (3)	
Hydraulics and Hydraulic Machinery		3 (5)
	18 (20)	18 (22)
Physical Training	2 (6)	2 (6)
	20 (26)	20 (28)

* *Note:* Figures in parenthesis indicate contact hours per week in class and laboratory. Figures outside of parenthesis indicate the number of meetings per week in class and laboratory.

	Periods per week* 1st term	2nd term
CURRICULUM V. *E-V(S), O-V(S), A-V(S). Engineer Specialist Candidates.*		
(a) Mechanical, Steam Engines.		
(b) Mechanical, Internal-Combustion Engines.		
(c) Electric, Power.		
(d) Electric, Communication.		
Calculus I, II	4 (4)	4 (4)
Chemistry Ia-IIa, and Engineering Materials	4 (6)	4 (6)
Analytical Mechanics I, II		5 (5)
Economics I-II, Principles of	3 (3)	3 (3)
Naval History and Elementary Strategy	3 (3)	
Kinematics (a, b) or Calculus III—Differential Equations (c, d)		2 (2 or 4)
Psychology I—General (a, b) or Electricity and Magnetism (c, d)	3 (3 or 5)	
	17 (19 or 21)	18 (20 or 22)
Physical Training	2 (6)	2 (6)
	19 (25 or 27)	20 (26 or 28)

THIRD COLLEGE YEAR

	1st term	2nd term
CURRICULUM I. *CEC-V(S). Civil Engineer Corps Candidates.*		
Thermodynamics Ia and Heat Power Ia	3 (3)	3 (5)
Electrical Engineering I, II	3 (5)	3 (5)
Strength of Materials I	3 (3)	
Materials Laboratory I		3 (7)
Fluid Mechanics		3 (5)
Curves and Earthwork	3 (5)	
Structures I, II, III	5 (7)	6 (10)
	17 (23)	18 (32)
Physical Training	2 (6)	2 (6)
	19 (29)	20 (38)

	1st term	2nd term
CURRICULUM II. *CC-V(S). Construction Corps Candidates.*		
Thermodynamics I and Heat Power I	5 (5)	5 (9)
Electrical Engineering I, II	4 (6)	4 (6)
Strength of Materials I	3 (3)	
Materials Laboratory I		3 (7)
Fluid Mechanics		3 (5)
Mechanical Processes	3 (3)	
Structures Ia, IIa	3 (5)	3. (5)
	18 (22)	18 (32)
Physical Training	2 (6)	2 (6)
	20 (28)	20 (38)

* *Note:* Figures in parenthesis indicate contact hours per week in class and laboratory. Figures outside of parenthesis indicate the number of meetings per week in class and laboratory.

	Periods per week* 1st term	2nd term
CURRICULUM III. *E-V(G). Engineering Candidates.*		
Thermodynamics I and Heat Power I	5 (5)	5 (9)
Electrical Engineering I, II	3 (5)	3 (5)
Strength of Materials Ia	3 (5)	
Kinematics and Design I, II	3 (5)	3 (5)
Naval Machinery		3 (5)
Radio Engineering I-II	2 (4)	2 (4)
Economics I-II, Principles of	2 (2)	2 (2)
	18 (26)	18 (30)
Physical Training	2 (6)	2 (6)
	20 (32)	20 (36)
CURRICULUM IV. *E-V(S), A-V(S), O-V(S). Engineer Specialist Candidates.*		
(*a*) and (*b*) Steam and Internal-Combustion Engines.		
Thermodynamics I and Heat Power I	5 (5)	5 (9)
Electrical Engineering I, II	4 (6)	4 (6)
Strength of Materials I	3 (3)	
Materials Laboratory I		3 (7)
Machine Design	3 (5)	
Fluid Mechanics		3 (5)
Mechanical Processes	3 (3)	
Mechanics of Machinery		3 (5)
	18 (22)	18 (32)
Physical Training	2 (6)	2 (6)
	20 (28)	20 (38)
CURRICULUM V. *E-V(S), A-V(S), O-V(S). Engineer Specialist Candidates.*		
(*c*) Electric, Power.		
Electric and Magnetic Circuits I-II	5 (9)	5 (9)
D.C. Machinery and Storage Batteries I		5 (9)
Thermodynamics Ia and Heat Power Ia	3 (3)	3 (5)
Strength of Materials I	3 (3)	
Materials Laboratory Ia		2 (4)
Kinematics	2 (4)	
Fluid Mechanics		3 (5)
Electrical Measurements	5 (9)	
	18 (28)	18 (32)
Physical Training	2 (6)	2 (6)
	20 (34)	20 (38)

* *Note:* Figures in parenthesis indicate contact hours per week in class and laboratory. Figures outside of parenthesis indicate the number of meetings per week in class and laboratory.

	Periods per week* 1st term	2nd term
CURRICULUM VI. *E-V(S), A-V(S), O-V(S). Engineer Specialist Candidates.*		
(*d*) Electric, Communication.		
Electric and Magnetic Circuits I-II	5 (9)	5 (9)
Thermodynamics Ia and Heat Power Ia	3 (3)	3 (5)
Strength of Materials I	3 (3)	
Materials Laboratory Ia		2 (4)
Electron Tubes and Circuits Ib-IIb	2 (4)	3 (5)
Electrical Measurements	5 (9)	
D.C. Machinery and Storage Batteries Ia		3 (5)
Kinematics		2 (4)
	18 (28)	18 (32)
Physical Training	2 (6)	2 (6)
	20 (34)	20 (38)

FOURTH COLLEGE YEAR

	1st term	2nd term
CURRICULUM I. *CEC-V(S). Civil Engineer Corps Candidates.*		
Structures IV, V	5 (9)	5 (9)
Sanitary Engineering		3 (5)
Water Supply	3 (5)	
Contracts and Specifications		2 (2)
Soil Mechanics	3 (5)	
Technical Reports	2 (2)	
Airport Design		3 (5)
Industrial Organization		3 (3)
Highway Engineering	4 (6)	
Economics of Engineering I, II	2 (2)	2 (2)
	19 (29)	18 (26)
Physical Training	2 (6)	2 (6)
	21 (35)	20 (32)
CURRICULUM II. *CC-V(S). Construction Corps Candidates.*		
Heat Power II, III	5 (9)	5 (9)
Structures IIIa, Va	3 (5)	3 (5)
Electron Tubes and Circuits Ia-IIa	2 (4)	2 (4)
Contracts and Specifications		2 (2)
Naval Machinery	2 (4)	
Metallurgy	3 (5)	
Aerodynamics		3 (3)
Industrial Organization	3 (3)	
Refrigeration		3 (5)
	18 (30)	18 (28)
Physical Training	2 (6)	2 (6)
	20 (36)	20 (34)

* *Note:* Figures in parenthesis indicate contact hours per week in class and laboratory. Figures outside of parenthesis indicate the number of meetings per week in class and laboratory.

	Periods per week* 1st term	2nd term
CURRICULUM III. *E-V(S), A-V(S), O-V(S).*		
Engineer Specialist Candidates.		
(*a*) and (*b*) Steam and Internal-Combustion Engines.		
Heat Power II, III	5 (9)	5 (9)
Naval Machinery	2 (4)	
Metallurgy	3 (5)	
Aerodynamics		3 (3)
Industrial Organization	3 (3)	
Refrigeration		3 (5)
Mechanical Design I, II	3 (5)	3 (5)
Electron Tubes and Circuits Ia-IIa	2 (4)	2 (4)
Contracts and Specifications		2 (2)
	18 (30)	18 (28)
Physical Training	2 (6)	2 (6)
	20 (36)	20 (34)
CURRICULUM IV. *E-V(S), A-V(S), O-V(S).*		
Engineer Specialist Candidates.		
(*c*) Electric, Power.		
Elective		3 (3)
Electron Tubes and Circuits I-II	2 (4)	4 (6)
Alternating-Current Machinery I	5 (7)	
Electrical Design I		3 (7)
Electrical Engineering Laboratory		3 (5)
Naval Machinery		2 (4)
Contracts and Specifications	2 (2)	
Psychology I—General	3 (3)	
Industrial Organization		3 (3)
Mechanical Processes	3 (3)	
Machine Design	3 (5)	
	18 (24)	18 (28)
Physical Training	2 (6)	2 (6)
	20 (30)	20 (34)
CURRICULUM V. *E-V(S), A-V(S), O-V(S).*		
Engineer Specialist Candidates.		
(*d*) Electric, Communication.		
Elective		3 (3)
Naval Machinery		2 (4)
Alternating-Current Machinery Ia	4 (6)	
High-Frequency Circuits I-II	5 (7)	5 (7)
Electrical Design Ia		2 (4)
Electrical Engineering Laboratory		3 (5)
Psychology I—General	3 (3)	
Industrial Organization		3 (3)
Machine Design	3 (5)	
Fluid Mechanics	3 (5)	
	18 (26)	18 (26)
Physical Training	2 (6)	2 (6)
	20 (32)	20 (32)

* *Note:* Figures in parenthesis indicate contact hours per week in class and laboratory. Figures outside of parenthesis indicate the number of meetings per week in class and laboratory.

EXAMINATIONS *

BY R. H. FRAZIER

Associate Professor of Electrical Engineering,
Massachusetts Institute of Technology

I am pleased to have the subject, *examinations*, included under the general topic, *instructional methods*, because I prefer to think about examinations in terms of educational devices rather than purely in terms of measuring devices.

In thinking about examinations and in using them, I believe that many of us, in comparison, are not quite up to the level of the sophomore in the electrical-measurements laboratory. To him an instrument is merely a box having several terminals and an indicator on a scale labelled "volts," "amperes," or something else, which he inserts in a circuit to make the desired measurement. The sophomore sometimes puts the ammeter across the line; but even if he knows that he wants to measure volts, and so selects an instrument labelled "volts" and connects it across the points between which the voltage is to be determined, he rarely realizes that the insertion of the instrument into the circuit may have seriously altered the circuit conditions, so that the indication of the instrument may be grossly different from the voltage that existed between the two points prior to the insertion of the instrument.

Now, the sophomore can find many ways to throw his electrical measurements askew other than by improper selection of the kind of instrument or by failure to make allowance for the circuit disturbance that insertion of the instruments may cause. However, those two aspects of the laboratory problem are the principal analogies I wish to use for examinations.

I believe that in setting examinations too few of us give sufficient thought to deciding adequately what the examination is supposed to determine, and too little effort in the selection of the kind of examination which best fulfills the requirements. The process of setting examinations year by year is likely to fall into the realm of habit and tradition. In some instances, professors continue to set them merely in obedience to faculty rules, but with the protest that they know all about the students anyhow and can just as well grade them on the basis of observed classroom work. The failure to decide what is desirable for the examination to accomplish is

* Presented at the meeting of the New England Section, S. P. E. E., Wentworth Institute, Oct. 17, 1942.

equivalent to failure to formulate the objectives of the instruction, and, as such, evinces in my opinion a very fumbling educational procedure. However, fumbling around for the right kind of examination, after the professor knows what he wants, is very excusable, because far too little is known about the properties of various kinds of examinations that have been developed. We have objective and subjective examinations, oral and written examinations, comprehensive, short-question, problem, project, and essay examinations. What do all these names mean, what do the various kinds of examinations accomplish, and how should the results be interpreted? (As an aside, I may mention that in my electric-circuit classes we find a real problem arising from the *amount* of material to be read in the time available. As a preliminary to a study to see what can be done about it, we recently gave a standard general reading test under the direction of Miss Margaret Lane, Assistant Vail Librarian. The one part that came out rather uniformly high was poetry comprehension, which was left in as part of the test merely because leaving it in was easier than taking it out. As a consequence, we are considering making our weekly assignments in rhyme.)

Unavoidably associated with the problem of stating objectives and selecting the kind of examination that best meets them, is the circumstance that the examinations are substantial components of the educational process. This is the principal thought that I wish to emphasize in my talk. An examination therefore should not be viewed primarily as a portable type of instrument that can be inserted here or there when desired, without disturbing the system into which it is inserted, but rather as an instrument built into the system, whose presence influences the workings of the system and whose indications must be interpreted in the light of that influence. Furthermore, since examinations do exert a substantial influence upon the workings of the educational system, by setting standards and by influencing the attitude of the student and his method of study, they should be designed so as to make their influence educationally desirable rather than educationally harmful. Unfortunately, many examinations seem to have an influence that is educationally harmful: They encourage snap judgments, emphasize the immediate and fragmentary items of a single course, encourage pure fishing for the answer most probably desired by the professor, utilize terminology local to one classroom, perpetrate ambiguities, and in general tend to become ends in themselves, from the student point of view, owing to the practical necessity of striving for passing grades.

Evidence of the unsatisfactory state of examinations is the common attitude among students that many examinations are a

purely burdensome procedure that contributes little to their understanding of a subject and adds considerable mental hazard. This fear of examinations seems to have more basis than can be explained by natural nervousness or feeling of impending doom owing to neglect of study. The fear is based in part (whether rightly or wrongly) upon a rather strong conviction that the examinations have insufficient significance in terms of the interpretations and judgments based upon them.

Thus far I have merely stated a problem and have offered no solution; in fact, in the present state of development of the examination art, I can go little farther than to state may belief that much of the solution lies in the increased development and use of comprehensive examinations and in the use of outside examiners, at least sufficiently "outside" to be divorced from the direct classroom and laboratory instruction of the examinees. In concluding my talk, therefore, I wish to put in a word for the work of the Committee on Comprehensive Examinations (of this Society), with which I have been associated for several years.

A few years ago, we decided that we must start on this problem at the bottom, that our thinking about examinations was very disorganized, and that we even lacked adequate terminology upon which to organize our thinking. Therefore we devoted most of our effort a few years ago to the proper development of committee organization, and to the development of terminology. I have here for distribution, reprints of the fruits of our first effort on terminology and specifications,* which appears under my name but includes the efforts of others, with due acknowledgments.

Last year the Committee made some progress in engaging in mutual coöperation with the various state boards of examiners for licencing engineers, in studying the problem of specifications and uses of comprehensive examinations. Though the work of the Committee now is practically at a standstill owing to the preoccupation of the members with more pressing duties, I shall be glad to receive from any of you, for the Committee files, comments or criticism which the preliminary work on terminology and specifications described in the reprint may arouse.

Summary

1. An examination is not purely a measuring instrument having no influence upon the educational system into which it is inserted.

* "On Terminology and Specifications for Comprehensive Examinations in Engineering," *Journal of Engineering Education*, Vol. XXXII, Nov. 1941, pp. 239–246.

2. Since the examination becomes an important component of the educational system into which it is inserted, it should be designed so as to have an influence which is educationally desirable.

3. The increased use of comprehensive examinations and outside examiners seems to be the most promising means in sight for making major improvement in the educational influence of examinations.

4. Much basic study is needed, such as has been initiated by the Society's Committee on Comprehensive Examinations, to straighten out our thinking about examinations and to place our practice in using them on sound bases.

A PROJECT OF THE MATHEMATICS DIVISION

By JOHN W. CELL

Secretary, Mathematics Division, S. P. E. E.

Several years ago, in an exchange of letters, certain members of the Mathematics Division of the Society for the Promotion of Engineering Education indicated a desire for a concrete project which would increase the effectiveness of mathematics instruction in engineering colleges. The late Professor J. H. Weaver, of Ohio State University, took an active part in this correspondence and, at the annual S. P. E. E. meeting held at Texas A. & M. in the summer of 1938, brought this correspondence to the attention of the assembled members of the Mathematics Division. Authorization was made for the formation of a committee to collect engineering problems illustrating mathematics, and suitable for use in teaching freshman and sophomore mathematics courses. The committee, appointed in the fall of 1938, consisted of Professors W. C. Krathwohl (Math., Illinois Institute), R. V. Churchill (Math., Michigan), Alan Hazeltine (Physics and E.E., Stevens), D. L. Holl (Math., Iowa State), E. M. Pugh (Physics, Carnegie), B. R. Teare, Jr. (E.E., Carnegie), J. H. Weaver (Math., Ohio State), and J. W. Cell (Math., N. C. State), chairman.

The "Report on the Aims and Scope of Engineering Curricula" (JOURNAL OF ENGINEERING EDUCATION, v. 30, March 1940, pp. 563–564) states that

"The scientific-technological studies should be directed toward:

1. Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing. This implies:

a. grasp of the meaning of physical and mathematical laws, and knowledge of how they are evolved and of the limitations in their use;

b. knowledge of materials, machines, and structures.

2. Thorough understanding of the engineering method and elementary competence in its application. This requires:

a. comprehension of the interacting elements in situations which are to be analyzed;

b. ability to think straight in the application of fundamental principles to new problems; . . . .

In an address given in December, 1940, to the National Council of Teachers of Mathematics Dr. Marston Morse said:

"Teachers of mathematics should present to their pupils technological and industrial applications whenever possible. This can and should be done without abandoning the concept of mathematics as a general tool."

Since 1938 the committee has gathered problems which illustrate the uses of mathematics, especially in junior and senior engineering courses. At the S. P. E. E. meeting held in the summer of 1941 at the University of Michigan, this committee presented a preliminary report consisting of 430 problems in typewritten form. The Mathematics Division authorized a preliminary edition and named an editorial committee consisting of Professors G. E. Moore (Math., Illinois), J. H. Weaver, and J. W. Cell, chairman. Through the support of President Doherty of the Carnegie Institute of Technology, a grant-in-aid was secured from the Carnegie Corporation of New York City to finance the entire cost of a preliminary edition of 100 copies. These lithoprinted copies were circulated with the request for corrections, suggestions, and additional problems.

At the S. P. E. E. meeting held in New York City in the summer of 1942, the editorial committee requested and received from the Mathematics Division and from the S. P. E. E. authorization to publish these problems in book form as a report of the Mathematics Division, under the auspices of the S. P. E. E. The Mathematics Division thereupon appointed a revision committee, consisting of Professors W. C. Brenke (Math., U. of Nebraska), G. E. Moore, C. C. Torrance (Math., Case), and J. W. Cell, chairman. This committee revised the preliminary edition and added some problems. The final edition contains 510 problems. A non-royalty contract was made with the McGraw-Hill Book Company who, on their part, agreed to publish at a minimum per copy cost. The problem collection is now in press and will soon be ready for distribution.

Most of the problems are so stated that they are suitable for direct assignment to average and superior students. Some problems, marked with asterisks, would more properly be used in outline form in the classroom or for bulletin board display. Some engineering terminology is necessary in the problem statements; but the committees have tried to keep the use of unfamiliar terms to a minimum, and have resorted at times to somewhat crude translations into non-technical language. However, many engineering freshmen have some technical vocabulary derived from high school courses or from hobbies.

These problems by no means imply that mathematics courses should be solely utilitarian. It is important, furthermore, that the problems be used as supplementary material and for their avowed purposes. The necessary drill problems must continue to be of the traditional variety. *This collection will be misused if there is any attempt to teach junior or senior engineering concepts in the freshman or sophomore mathematics classroom.*

If teachers of engineering mathematics can use these problems to increase the effectiveness of mathematics instruction, and if engineering students find in them a challenging interest, then the work of these three committees will be genuinely rewarded.

REPORT FOR 1942–43 COMMITTEE ON GRADUATE STUDY, S P. E. E.

The Committee on Graduate Study had one meeting, several conferences between pairs of its members, and regular correspondence during the academic year 1942–43. This time was devoted to the establishment of the long-term function of the committee since it became evident at once that complete recommendations covering the broad fields of Objectives, Procedures, and Requirements for Advanced Degrees could not be made after a study of one or perhaps even two years. It was also understood that some time would be consumed in observing trends before recommendations for post-war procedures could be made.

Importance of Graduate Work

There is agreement that engineering graduate study will increase greatly after the war and that its relative importance as a contribution to the total educational picture will grow. There is a belief that definite provision for graduate study is essential. "Engineering colleges have carried graduate work and research work rather as a side line, without having made complete provision for it. This should be changed and the larger schools should make definite provisions for graduate study, just as they now do for undergraduate students. It is not sufficient for a student to study a fifth year and take some courses regularly offered to seniors which he did not have time to take." Another writer comments, "I think we can certainly say that some engineering colleges have made definite provision for graduate work . . . a small school concentrating on graduate work may have some advantages."

Emphasis is placed upon the significance of graduate study as an indirect but vital influence upon undergraduate teaching. "I think that the chief function of our universities is to educate the undergraduates. I also think no technical institution is likely to be first class unless it effectively develops graduate study. In our field a teacher who does not habitually do independent thinking—I am somewhat averse to the overworked word 'research'—is not likely to show the undergraduate how to think. The graduate school then could create an atmosphere in which independent thinking is necessary; this atmosphere is needed for good undergraduate work."

Research

There is no confusion as to the important function that research plays in the Graduate School. "As regards the student, we are trying to train him to be an independent thinker and investigator." There is skepticism, however, as to the need for requiring each thesis to be a contribution to science. "A good deal of attention is given at times to the obligation of the university to add, through its graduate work, to the sum total of human knowledge. I think this is usually nonsense as regards graduate study . . . contributions in graduate theses valuable to the community almost always come from the faculty."

Other Objectives

Whether the major objective of graduate study is to specialize the student narrowly or to broaden his vision remains wide open for discussion. Industry usually expresses its interest in graduate students—particularly doctorates—on the basis of specialization. "The basis (for the Ph.D degree) for engineers is that the man qualifying for the degree not only has outstanding competence in the engineering field, but also has a liking for advanced mathematics and physics and has the ability to equal mathematicians and physicists in grasping these subjects." "The objectives should be to train men for design, research, and development." "Although graduate physicists and chemists are important in industry, there is also a great need for men who have been trained in the applications of mathematics, physics, and chemistry to engineering problems and who have a keen appreciation of the limitations which must always be considered in commercial work."

The opposite or liberal point of view has supporters. "Graduate study is usually too narrow and too narrowing. Good men are often harmed by too great specialization in graduate study; this need not and should not be true." "Is this the appropriate time to debate the possibilities of devoting Minor requirements to the development of skills which may contribute to public service rather than those which are aimed at increasing individual professional proficiency?" "Graduate study should consist of a continuation of the study of fundamental sciences, a review of those subjects imperfectly understood by the undergraduate, an extension of topics briefly treated on the undergraduate level, and the introduction of advanced material requiring undergraduate courses as prerequisites."

Procedures and Requirements

Quotations will quickly point out the problems that need discussion on institutional procedures. "I think the matter of admission should be left to individual departments." "Satisfactory grades are not sufficient. They should be coupled with a real desire for learning and research." "In respect to the 1100 masters' degrees and the 144 doctors' degrees in engineering in that year, I wonder what degree of uniformity in requirements exists among the various engineering schools that awarded these degrees." "The admission of qualified undergraduates (seniors) is not only to be permitted but encouraged, when the student is qualified and will be benefitted by such study." "The professional degree (6 year course) may be granted by the several departments." "There is an advantage in having students returned to these theoretical studies (mathematics, physics, and chemistry) rather than having the theoretical studies given in a longer undergraduate program."

Details of Operation

The following comments refer to degrees, residence, languages and thesis requirements. "I do not believe that the engineering colleges should keep complete jurisdiction over their graduate students and give them a special degree such as Doctor of Engineering." Another committee member says, "Based upon tradition and the concept 'love of learning,' the Ph.D. is the most appropriate." "I believe we will agree to a minimum of thirty weeks of full-time work for the master's and ninety weeks for the doctor's degree. Full-time I think means just that . . . the man is *not* devoting a considerable part of his time to work unrelated to his studies." "The requirements for foreign language are too arbitrary." "I think the thesis an important part of training for the master's degree." Another writer disagrees, "The master's degree does not ordinarily stand for ability in research, but more generally for mastery of the subject. For the doctorate, of course, the nucleus of the degree is the ability to carry on a satisfactory research."

A Panel Discussion

In view of the many problems opened for discussion by the work of the Committee on Graduate Study in 1942–43, it is thought that a panel discussion would prove useful at the annual meeting in Chicago in June 1943. It is planned to invite about twenty persons who have special association with graduate students and

graduate programs to sit around a table and participate in an open discussion of these problems through a two-hour session. All others will be invited to be present as auditors. All discussion will be taken down by a secretary and this running report will be expected to form the basis of the committee's study for the coming year. After its careful analysis and study by the committee, this report should ultimately give rise to a series of recommendations concerning the Objectives, Requirements, and Procedures of graduate study in engineering.

L. E. GRINTER, *Chairman*,
JOHN W. M. BUNKER,
HARDY CROSS,
H. J. MASSON,
R. W. SORENSEN,
ALFRED H. WHITE.

NEW MEMBERS

ANDREASSEN, ALEXANDER T., Tutor in Civil Engineering College, City of New York, New York City. J. J. Theobold, C. Ramberg.

AVEY, HARRY T., Associate Professor of Mechanics, University of Wisconsin, Milwaukee, Wis. H. E. Grant, B. G. Elliott.

BACKER, GERALD H., Associate Professor of Applied Mechanics, University of Kentucky, Lexington, Ky. R. D. Hawkins, E. A. Bureau.

BAILEY, ALBERT D., Instructor in Electrical Engineering, University of Illinois, Urbana, Ill. M. A. Faucett, G. R. Peirce.

BASKERGILL, WILLIAM H., Associate Professor of Chemical Engineering, University of Tenn., Knoxville, Tenn. R. M. Boarts, R. W. Morton.

BIBERSTEIN, FRANK A., Associate Professor of Civil Engineering, Catholic University, Washington, D. C. F. L. Bishop, Nell McKenry.

BILLHARTZ, WM. H., Professor of Physics, Franklin College of Indiana, Franklin, Ind. F. L. Bishop, Nell McKenry.

BOGEMA, MARVIN, Assistant Professor of Hydraulics, Cornell University, Ithaca, N. Y. L. D. Doty, C. L. Walker.

BRAZDA, LUMIR P., Instructor in Architecture and Engineering, Wilson City College, Chicago, Ill. F. L. Bishop, Nell McKenry.

BURROUGHS, FREDERICK D., Educational Director, Utilities Engineering Institute, Chicago, Ill. F. L. Bishop, Nell McKenry.

BYERLAY, HENRY L., Professor of Electrical Engineering, Lawrence Institute of Technology, Highland Park, Mich. F. L. Bishop, Nell McKenry.

CHAMBERS, CARL C., Associate Professor of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. Harold Pender, C. D. Fawcett.

CLUVERIUS, WAT T., President, Worcester Polytechnic Institute, Worcester, Mass. F. W. Roys, J. W. Howe.

CROUSE, WILLIAM H., Service Engineer, Delco-Remy Div., G.M. Corporation, Anderson, Ind. F. L. Bishop, Nell McKenry.

DAVIDSON, GEORGE A., Assistant Professor of Electrical Engineering, Oklahoma A. & M. College, Stillwater, Okla. A. Naeter, E. R. Stapley.

DYE, EDWARD R., Professor and Head, Dept. of Civil Engineering, Montana State College, Bozeman, Mont. M. R. Good, R. T. Challender.

ELLIOTT, ROY W., Comptroller, Municipal University of Wichita, Wichita, Kansas. E. D. Hay, V. P. Hessler.

FISCHER, BERNHARD, Instructor in Electronics and Math., University of California, Berkeley, Calif. F. L. Bishop, Nell McKenry.

FOSTER, CHARLES A. B., Assistant Professor of Engineering and Manager, Va. Poly. Inst., Richmond, Va. F. L. Bishop, Nell McKenry.

GOODE, HENRY P., Assistant Professor of Mechanical Engineering, Stanford University, Calif. E. L. Grant, A. S. Niles.

GORDER, LESLIE O., Professor of Radio, Chicago Technical College, Chicago, Ill. F. L. Bishop, Nell McKenry.

HARRIS, BOYD T., Representative, The Macmillan Co., 60 Fifth Avenue, New York City. F. L. Bishop, Nell McKenry.

HARRIS, L. DALE, Instructor in Electrical Engineering, University of Utah, Salt Lake City. A. L. Taylor, R. H. Hull.

HONNELL, MARTIAL A., Asst. Prof., Head, Communications Div. Electrical Engineering Dept., Ga. School Tech, Atlanta, Ga. R. L. Sweigert, D. P. Savant.

JACOBS, ROY K., Associate in T. & A. Mechanics, University of Illinois, Urbana, Ill. N. E. Ensign, F. B. Seely.

JOHNSON, EMORY E., Assistant Professor of Civil Engineering, S. D. State College, Brookings, S. D. C. C. Oleson, H. Blickensderfer.

JUDY, CLINTON K., Professor of English, California Institute of Technology, Pasadena, Calif. Franklin Thomas, R. W. Sorensen.

KEPLER, FRANK R., Supervisor, Dept. Voc. Ed., Asst. Prof. Industrial Arts Ed., Detroit Public Schools, Detroit, Mich. A. R. Alliason, R. H. Schoonover.

LA PIERCE, WALTER A., Instructor in Electrical Engineering, Columbia University, New York City. W. A. Curry, J. A. Balmford.

LUZADDER, WARREN J., Assistant Professor of Engineering Drawing, Purdue University, Lafayette, Ind. J. N. Arnold, D. W. Thomas.

MACK, DAVID J., Assistant Professor of Chemical Engineering, University of Tennessee, Knoxville, Tenn. R. M. Boarts, R. W. Morton.

MEDLIN, JOHN W., Instructor in Mechanical Engineering, University of Wisconsin, Madison, Wis. B. G. Elliott, Noble Sherwood.

MORKOVIN, DIMITRY, Instructor in T. & A. Mechanics, University of Illinois, Urbana, Ill. F. B. Seely, J. O. Draffin.

MORTLAND, JAS. A., Assistant Professor of Engineering Drawing, University of Tampa, Tampa, Fla. F. L. Bishop, Nell McKenry.

OGLESBY, JOHN L., Instructor in Chemical Engineering, University of Tennessee, Knoxville, Tenn. C. R. Plummer, R. M. Boarts.

PEEBLES, JOHN B., Chairman, Div. of Engineering, Emory University, Atlanta, Ga. F. L. Bishop, Nell McKenry.

PESMAN, GERARD J., Assistant Professor of Mechanical Engineering, Montana State College, Bozeman, Mont. R. E. Gibbs, E. W. Schilling.

REYHNER, THEODORE O., Instructor in Physics, The Cooper Union, New York City. Hugh Halsey, G. F. Bateman.

SHUTTS, WILLIAM H., Instructor in Mechanical Engineering, University of Colorado, Boulder, Colo. Warren Raeder, H. S. Evans.

SMITH, WILLIAM C., Assistant Professor of Electrical Engineering, University of Maryland, College Park, Md. L. J. Hodgins, J. H. Clouse.

SODERBERG, C. RICHARD, Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. A. L. Townsend, J. H. Keenan.

SORENSEN, ELMER P., President, Utilities Engineering Institute, 1314 Belden Ave., Chicago, Ill. F. L. Bishop, Nell McKenry.

TARPLEY, CLARENCE E., Instructor in Engineering Mechanics, New York University, New York City. J. K. Vennard, H. E. Wessman.
TASKIN, HALDAN K., Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wis. J. R. H. Douglas, W. D. Bliss.
TEMPLE, VAN B., Professor of Mathematics and Engineering, Louisiana College, Pineville, La. F. L. Bishop, Nell McKenry.
THEURER, ELLEN K., In charge of Engineering Library, University of Michigan, Ann Arbor, Mich. H. E. Keeler, R. S. Hawley.
VARTERESSIAN, KEGHAM A., Instructor in Chemical Engineering, The Pennsylvania State College, State College, Pa. F. L. Bishop, Nell McKenry.
VISSAT, PETER L., Instructor in Experimental Engineering, Cornell University, Ithaca, N. Y. F. L. Bishop, Nell McKenry.
WATSON, HERBERT M., Radio Engineer, KBLW, 3622 Clinton Ave., Richmond, Calif. J. S. Thompson, F. L. Bishop.
WILSON, CLYDE H., Professor of Industrial Education, University of Tennessee, Knoxville, Tenn. R. T. Brown, A. T. Granger.
ZUR BURG, FREDERICK W., Head, Dept., Chemical Engineering, Southwestern Louisiana Inst., Lafayette, La. G. G. Hughes, H. R. Mason.
Associate Membership: BRADLEY POLYTECHNIC INSTITUTE, Peoria, Ill., F. R. Hamilton, President.

299 individual + 1 institutional member (new) this year.

COLLEGE NOTES

South Dakota School of Mines and Technology.—A name borne by the State School of Mines for the fifty-six years of the school's existence was changed by the South Dakota Legislature at its recent session. It is now the South Dakota School of Mines and Technology.

A new $200,000 administration-museum building was completed and dedicated last fall. It is called the "O'Harra Memorial Building" in honor of the late Dr. C. C. O'Harra, president of the school for twenty-four years.

SECTIONS AND BRANCHES

The Fall Meeting of the **New England Section** of the Society was held at Wentworth Institute, Boston, Massachusetts, on Saturday, October 17, 1942. The total registration was 247 members and guests.

The following conferences were held:

A. Chemical Engineering—Room 5, Attendance 30.
   Chairman: C. A. Brautlecht, University of Maine.
   The Accrediting Program of the American Institute of Chemical Engineers. Albert B. Newman, Dean of the School of Technology, College of the City of New York; Chairman of the Accrediting Committee of the A.I.Ch.E.
   What Does the Industrialist Want in Undergraduate Chemical Engineering Training? John Healy, Director of Development and in Charge of Procurement of Technical Men, Merrimac Division, Monsanto Chemical Company.

B. Civil Engineering—Room 14, Attendance 20.
   Chairman: A. D. Taylor, Norwich University.
   The Use of Models and Demonstration Equipment as Aids in Teaching Soil Mechanics to Undergraduates. Russell R. Skelton, University of New Hampshire.
   Sanitary Engineer as a Profession. E. Sherman Chase, Metcalf and Eddy.
   Discussors: Ralph W. Horne, Fay, Spofford and Thorndike; Edward W. Wright, Massachusetts Department of Public Health.

C. Drawing, Design and Shop—Drawing Room 4, Attendance 14.
   Chairman: Arthur W. Leighton, Tufts College.
   Dimensional Control. A. G. Beal, Production Engineer, The Foxboro Company.
   The Relation of Engineering Drawing to Plant Engineering. Philip Wilmarth, Plant Engineer, Blanchard Machine Company.

D. Economics—Room 9, Attendance 8.
   Chairman: W. S. Lake, Northeastern University.
   Should War Economics Be Emphasized?

E. Electrical Engineering—Auditorium, Attendance 44.
   Chairman: Victor Siegfried, W.P.I.
   What Mathematical College Training Industry Expects from Young Engineers. A. R. Stevenson, Jr., General Electric Company.

Discussors: C. A. Powell, Westinghouse Electric and Mfg. Co.; Wayne E. Keith, New England Telephone and Telegraph Co.

F. Engineering School Libraries—Room 6, Attendance 15.
Chairman: Mrs. Ruth McG. Lane, M.I.T.
Instruction of Engineering School Students in Library Usage and Research.
Educational Responsibilities of Engineering School Librarians.
Technical Institute Libraries.

G. English and Engineering Education—Room 4, Attendance 28.
Chairman: H. R. Bartlett, M.I.T.
Making Composition Teaching More Effective. Charles Kerby-Miller, Wellesley College.
Discussors: Frederick W. Holmes, Northeastern University; Kenneth L. Knickerbocker, R.I.S.C.

H. Mechanical Engineering—Room 12, Attendance 40.
Chairman: R. W. Wales, R.I.State.
The Application of Dimensional Analysis to Experimental Work. A. H. Shapiro, M.I.T.
Relation of Aeronautics to the Course in Mechanical Engineering. I. I. Sikorsky, Vought-Sikorsky Aircraft.

I. Mechanics and Strength of Materials—Room 10, Attendance 15.
Chairman: F. N. Weaver, Tufts College.
Objectives and Methods in Materials Testing Laboratory Courses. E. D. Kingman, W.I.
Breadth vs. Depth in Strength of Materials Courses. D. G. Downing, W.P.I.

From 12:45 P.M. to 1:45 P.M. 149 members and guests enjoyed a Naval style luncheon in the cafeteria of Wentworth Institute. Following the luncheon, a brief business meeting was conducted with Dean Garran presiding. Dean Garran introduced Mr. Tudbury, Chairman of the Local Committee, who extended a welcome on behalf of Wentworth Institute. The secretary read the minutes of the 1941 meeting and presented the financial report up to October 15, 1942. The minutes and financial report were approved.

J. S. Thompson, Treasurer of the Society, was next presented and extended greeting on behalf of the officers of the national society. Dean Garran also called on past presidents C. Frank Allen and D. C. Jackson who made brief remarks. Wayne E. Keith, who had the responsibility of the News Bulletin for 1942, was next introduced.

Announcement was made that the section had invitations to hold its 1943 meeting outside of Boston but in view of the present transportation situation, it might be necessary for the meeting to be held in Boston again.

The afternoon meeting was held in the auditorium with an attendance of 132 and the following program:

General Theme—Instructional Methods.

Chairman: Frank W. Garran, Thayer School of Engineering, presiding.

Teaching Methods. J. W. Howe, W.P.I.

Visual Instruction. W. P. Kimball, Thayer School of Engineering.

Examinations. R. H. Frazier, M.I.T.

Wartime Demands for Engineers. T. K. Miles, War Requirements Unit, National Roster of Scientific and Specialized Personnel.

From 5:00 to 6:00 P.M. a showing of Navy movies was given in Room 4. The annual dinner was held at 6:15 P.M. in the auditorium—attendance 160.

Mr. Tudbury extended greetings to all those present on behalf of Mr. F. E. Dobbs, Principal of Wentworth Institute, who was prevented from being present due to illness in his family. The secretary announced that the total attendance was 247 with 19 schools and 9 industries represented. The highest attendance was from Northeastern with 42, Wentworth with 41, and M.I.T. with 37. In accordance with custom, the secretary read the constitution of the section.

R. D. Douglass, Chairman of the Nominating Committee, presented its report, nominating Frank W. Garran for Chairman, C. E. Tucker for Secretary, and C. L. Dawes for Sectional Representative on the National Nominating Committee for the ensuing year. Dean Garran then turned the chair over to Professor Morgan who put the nomination to vote and the secretary was authorized to cast one ballot for the nominees.

Dean Garran then called on W. C. White, Chairman of the Resolutions Committee, for its report. The following resolutions were presented and unanimously accepted by the section.

BE IT RESOLVED

that the New England Section of the Society for the Promotion of Engineering Education, mindful of the very gracious and thoughtfully planned hospitality that has been accorded its members and their guests by the faculty and faculty wives of Wentworth Institute throughout the annual meeting of the Section on Saturday, October 17, 1942, express to these generous hosts the sincere and hearty thanks of all who are privileged to share in the conferences today;

that the Section also voice its appreciation to Dean Frank W. Garran of the Thayer School of Engineering and to Professor Carlton E. Tucker of the Massachusetts Institute of Technology,

for their capable administration of the affairs of the Section during the troubled year in which our country was plunged into world wide war, to Professor Chester W. Tudbury of Wentworth Institute for the many hours he has so cheerfully given to the perfecting of arrangements for this fall meeting; and finally

that the Section extend its hearty thanks to Mr. Wayne E. Keith of the New England Telephone and Telegraph Company to whom it is once again indebted for the compiling of a very useful and interesting news bulletin.

Respectfully submitted,

William C. White, *Chairman*,
Frank M. Gager,
John H. Lampe.

The Chairman then introduced James H. Powers, Foreign Editor of the *Boston Globe*, who gave the address of the evening on the subject "How Long a War?—An Analysis of Hitler's Summer Campaign, and Its Bearing Upon War Plans." This address proved to be very interesting to those present.

Financial Report

October 15, 1942

Receipts

Cash in Bank October 15, 1941	$26.74
Receipts from Hanover Meeting	51.75
Interest	.53
	$79.02

Expenditures

Printing	$26.55
Postage	17.08
Mimeograph	3.50
Taxi delivering proof and programs	2.65
Cash in Bank	29.24
	$79.02

October 23, 1942

Net Receipts from Wentworth Meeting	$10.93

The officers of the **Southwest Section**, S. P. E. E., for 1943–44 are:

Chairman—H. F. Godeke, Texas Technological College, Lubbock, Texas.

Vice-Chairman—Vacancy—to be filled by executive committee.

Secretary-Treasurer—H. C. Dillingham, A. & M. College of Texas, College Station, Texas.

The 1943 Annual Meeting scheduled for Texas Technological College has been postponed to Spring Recess, 1944.

H. C. Dillingham, *Sec.*

THE T-SQUARE PAGE

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William E. Street, *Editor*

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CHANGES IN DRAWING CURRICULA

The Engineering Drawing teacher must be alert to different ideas and changes in drafting room practice to meet present day demands of industry. New and improved tools, together with changing methods of fabrication and assembly, create needs for improved drafting methods and more emphasis on subjects that have had very little attention previously.

Drawing like many other subjects is becoming more pressed for time yearly and modern trends in industry demand that the drawing teacher spend at least one hour or more a week in lecture and demonstration to give the student enough theory for him to familiarize himself in practice (laboratory) with the drafting field, especially since so many young engineers must spend some time in the drafting room. However, this drafting board experience gives him an excellent opportunity to acquaint himself with materials, design, and construction.

Pictorial representation is being given more consideration today than heretofore and Associate Professor J. G. McGuire, of the Engineering Drawing Department of Texas A. and M. College, points out this use in the following paragraphs.

As the E.S.M.W.T. Teacher of Drafting looks for things to better qualify his students for positions in industry, he should not overlook pictorial drawings as used by many aircraft industries at the present time.

This writer would like to call the reader's attention to an article entitled "Perspective Drawing Speed Plane Assembly" which appeared in the June, 1942, issue of *Aviation*. These so-called perspective drawings are known in the aircraft industry as "production illustrations." The principles of isometric and oblique are used. The pictorial drawings supplement, and in some cases take the place of, blueprints in the assembly line. In this way the untrained worker is enabled to work on an assembly with relatively little supervision. Such drawings, according to tests by aircraft companies (*Aviation*, June, 1942), save much time on the assembly line for the trained, as well as the untrained worker. The unique principle of this type of illustration is that "certain parts are pulled out of position when necessary, for clarity."

Many schools are now offering training in this type of drafting. In view of this trend, it may be well for the college engineering drawing departments to give consideration to the possibility of the incorporation of such a unit in the regular engineering drawing courses, as well as the E.S.M.W.T. training courses.

NEWS SQUIBS

The Engineering, Science, and Management War Training schools are rendering valuable service to the war effort. Professor W. G. Smith of the Defense Training Institute of the Engineering Colleges of Greater New York states "that they are qualifying people for jobs between the manual workers and the Engineering Graduates for a big field including inspectors, draftsmen, assistants, clerks, etc. This training includes the basic essentials in the first two years of engineering education."

Mr. A. M. Merrill, Principal Naval Architect, U. S. Navy Yard, Brooklyn, N. Y., sums up the Practical Application of Descriptive Geometry in the Shipyard and Drafting Room as follows:

"In applying the principles of descriptive geometry to the practical purposes of ship design, we are concerned with it as a branch of drawing or as a graphical language, our interest being in establishing the practical objectives toward which a drafting department in a technical or engineering school should work in preparing engineers and naval architects, rather than mathematicians or statistical computors. By practical objectives is meant the gaining of knowledge and skill in preparing engineering ship drawings of some complexity, developing the ability to think on paper, to solve problems graphically and to interpret technical design, using the geometrical laws which underlie the science of graphical expression to give an accurate representation of a ship, its structure, or parts thereon. Marine engineering and ship design require this ground work probably more than any other branch of technology, as in it are included the principal phases of technical design, wherein the theory and laws of orthographic projection, the true length of a line in space, plane surfaces and their intersections, curved lines and curved surface intersections, isometric drawing as an exact system, and other geometric principles, are all used extensively throughout the design.

"As far as drafting is concerned, we in ship design are not only interested in plotting and fairing the ship's lines, which are the contours of horizontal, vertical, transverse, and diagonal plane intersections as passed through the ship, all to be discussed later; but also in such phases of descriptive geometry as would be applicable to layout and three-view development work, that is required in the design of ship's structural, piping, ventilation, electrical and mechanical design work, and also in preparing clearance studies of lines of sights for navigational and other instruments, and lines of gun fire on naval vessels, assuming among other conditions those of rolling and pitching simultaneously."

Mr. Gene H. Brock of the Engineering Drawing Department of Texas A. and M. College explains the Silk Screen Process Printing for Preparing Posters in Color.

"Printing materials for silk screen process work may be purchased at most art supply stores: the printing frames for mounting the silk is a job of simple carpentry.

"The stencil is cut from Nufilm or Profilm, trade names for a thin film of colored synthetic material mounted on a glassine base or paper. Cutting the stencil is simply outlining the letters or design with a thin sharp stencil knife and peeling the film off the glassine. The stencil is then adhered to the silk. After the adhering liquid is dry the glassine is removed and the stencil is ready for printing.

"The frames that mount the stencil are hinged to a base so that proper registering of colors is possible. Printing is processed by pushing the paint through the stencil with a squeegee. A stencil must be prepared for each color used."

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

Interesting and useful reference material on what engineers are doing in selecting and training new personnel for the profession and in elevating the status of engineers in general is contained in the tenth annual report of Engineers' Council for Professional Development. Included in the report is a list of engineering curricula approved by E.C.P.D. as of October 18, 1942. Note that the curricula so accredited are those functioning before the recently announced Army and Navy college training programs became operative. A total of 551 curricula, at 131 institutions, are currently on the approved list. In addition, several other curricula, such as aeronautical and industrial engineering, are listed as options of the regular courses in some of the older curricula.

In his report, Robert E. Doherty, E.C.P.D. Chairman and President of Carnegie Institute of Technology, reviewed activities of the year, relating the Council's functions to present world conditions, and referred to the work of the several committees. Especially he referred to the E.C.P.D. conference in September to discuss the problems of engineering manpower. At this conference were representatives of several government agencies who are advisory to the War Manpower Commission regarding the reserves of professional and scientific men; also present were representatives of a number of war industries employing large numbers of engineers. As a result of this conference, a resolution was forwarded to the War Manpower Commission urging a more efficient use of available engineers and suggesting means for increasing their number.

The Committee on Student Selection and Guidance, R. L. Sackett, chairman, reported continuing assistance in the guidance of high-school students to a better understanding of the engineering field, and, particularly, summarized the findings of its study of tests and aptitudes of both arts and engineering students, as carried out in representative universities and high schools during the previous year.

Besides indicating progress in its usual activities, the Committee on Professional Training, Everett S. Lee, chairman, emphasized a new project—a manual for junior engineers—the preparation of which is now being undertaken. The Committee on Professional

Recognition, Charles F. Scott, chairman, reported activity in its program of stressing the professional phases of the engineer's life. To this end, over 10,000 copies of an address by President W. E. Wickenden, of the Case School of Applied Science, were sold, and the committee was also instrumental in its reprinting by several engineering society journals.

Certain "Canons of Engineering Ethics" were proposed by the Committee on Principles of Engineering Ethics, D. C. Jackson, chairman, which are printed in the E.C.P.D. Report. This attempt to formulate ethical standards for engineers in a written code follows similar codification of principles by some other professional groups. These canons have been referred to the boards of the constituent organizations for suggestions or acceptance.

Reports by representatives of the eight constituent societies included in E.C.P.D. are printed herein, as is also an account of the Council's annual dinner. The retirement of R. L. Sackett, emeritus dean of engineering, The Pennsylvania State College, from the chairmanship of the Committee on Student Selection and Guidance after ten years was noted, the dinner report containing the tribute to Dean Sackett.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Nominations for 1943–44

For President: ....

For 1st Vice Pres.: ....

For 2nd Vice Pres.: ....

For Members of Council for three years

(7 to be elected)

....

....

....

....

....

....

....

....

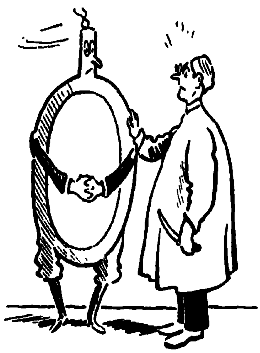
(signed) ....

(address)..

(date) ....

Names of nominees, "on the form provided," must reach the secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa., not later than May 15, 1943.

G-E Campus News



PLASTIC SURGERY

MISTER FIVE BY FIVE had nothing on radio antenna enclosures until the "doctors" of the G-E Plastics Laboratory (PhD's, not MD's) went to work on the problem of streamlining. The result was a plastic housing that a plane hardly knows it's carrying.

That's just one wartime activity of the chemists in the Laboratory. They're also concocting plastics for fuse caps on mortar shells and for a vast variety of parts for battleships, tanks, and what-have-you's.

The name "plastics" covers a lot of different materials. These G-E chemists are applying the most precise and ingenious chemical techniques to increase that variety. So, if a special job requires a material with combined properties that no existing material has, they go to work to cook up an entirely new plastic to fill the bill.

The whole story can't begin to be told yet. But when it can, you'll be amazed at how far plastics have gone in wartime, and how many new peacetime jobs they'll be ready to tackle afterward.

JAP NAP

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Full information on the Science Talent Search, including reprint of an article by Dr. Edgerton and Dr. Britt describing the methods employed, will be sent on request. Write to Science Service, 1719 N Street, Washington, D. C., or to School Service, Westinghouse Electric & Manufacturing Company, 306 Fourth Avenue, Pittsburgh, Pa.

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By F. L. BISHOP

Secretary of the Society

Another annual meeting of the Society will be held June 18–20, 1943, at the Drake Hotel, Chicago, Illinois—Illinois Institute of Technology and Northwestern University acting as hosts. This year we are celebrating the golden anniversary of the founding of the Society. Probably not more than seven or eight hundred members will be in attendance (under normal conditions we could expect about 2,000). Why do they come?

Have you stopped to analyze the motives of so many teachers who attend these meetings? Some travel many weary miles. Many come from very short distances. They sit beside you at the meetings. They talk to you and to others. They listen to the speakers. Ask questions. Disagree with the speakers. Present a new point of view. Attend numerous conferences.

Do you wonder why these teachers attend these meetings? They come to learn how to improve their teaching. What do they expect to take away? They cannot tell you in so many words but if you watch their teaching when they return to their classes, the improvement which is evident shows you what they have taken away. It is there in the classrooms that they put into action the things which they have learned at the meeting. Many pet ideas in regard to certain methods are discarded because these teachers are cognizant of the new trend in education and in training. This year, more than ever before, every member who can take the time away from his classes should attend the meeting in Chicago. There he will hear from representatives of the Army, the Navy, and the War Manpower Commission, in addition to other authorities on engineering education.

These, I think, are some of the opportunities which present themselves to those who attend our annual meetings. The inspiration "to carry on" is possibly the greatest contribution which the annual meeting has to make to each and every one who attends.

STAFF MEMBERS AND ENGINEERING ENROLLMENT, NOVEMBER, 1942

WAR MANPOWER COMMISSION
NATIONAL ROSTER OF SCIENTIFIC AND SPECIALIZED PERSONNEL

Staff Members, Graduate and Undergraduate Enrollment, and Maximum Enrollment Capacity in 166 Engineering Schools in the United States and its Territories as of November, 1942 /1\

		Aeronautical	Agricultural	Architectural	Ceramic	Chemical	Civil	Electrical	Industrial	Mechanical	Metallurgical	Mining	Marine and Naval architecture	Petroleum	General	Other	Total
Present number of staff members		193	98	164	54	576	930	927	146	1,161	185	82	21	37	188	1,065	5,826
Present number of full-time students who are candidates for degrees	Freshmen	2,165	341	468	122	5,449	3,788	4,459	968	9,049	647	353	31	438	16,654	711	45,620
	Sophomores	1,544	224	381	157	4,878	3,094	4,109	636	8,068	637	293	120	334	2,006	486	26,967
	Juniors	1,140	166	314	113	3,763	2,353	3,288	531	6,127	560	275	118	277	586	423	20,024
	Seniors	881	109	295	110	2,976	1,889	2,588	585	4,801	533	360	97	298	458	359	16,309
	5th yr. students	59	4	29	-	186	117	126	36	357	12	6	-	6	-	66	1,008
	Graduate students	133	7	17	14	227	126	176	11	141	47	14	28	8	20	201	1,171
	Special students	16	2	5	-	25	19	101	1	39	333	1	-	1	5	71	619
Total - full time students - - - -		5,938	853	1,509	516	17,504	11,386	14,847	2,767	28,582	2,759	1,292	396	1,369	19,689	2,517	111,718
Present number of part-time and evening students who are candidates for degrees	Freshmen	275	15	47	28	430	393	760	54	1,273	9	94	-	2	1,230	35	4,643
	Sophomores	56	-	3	-	116	80	204	11	369	28	40	-	-	32	4	946
	Juniors	37	-	-	-	175	98	267	24	413	39	30	-	-	56	1	1,140
	Seniors	170	-	5	-	188	72	190	32	253	99	-	-	8	11	7	1,082
	5th yr. students	-	-	-	-	15	10	28	1	44	4	-	-	-	-	-	102
	Graduate students	33	1	6	-	378	137	606	60	330	180	63	-	5	111	66	1,936
	Special students	170	-	10	-	205	134	406	12	668	259	1	-	2	1,140	150	3,137
Total.- part time students - - - -		741	16	71	28	1,504	924	2,461	194	3,360	568	228	-	17	2,580	252	12,934
TOTAL NUMBER OF STUDENTS - - - - -		6,679	869	1,580	544	19,008	12,310	17,308	2,691	31,932	3,327	1,520	396	1,376	22,269	2,569	124,647
Estimated number of full-time students who could be taught with present facilities and staff	Under-grad	6,295	1,936	2,438	778	19,944	16,304	18,832	3,870	30,648	3,561	2,263	534	1,885	21,396	3,313	133,898
	Grad.	240	133	164	80	1,006	702	793	211	1,219	272	124	58	71	79	391	5,538
Estimated number of part-time and evening students who could be taught with present facilities and staff	Under-grad	1,185	90	165	28	2,301	2,367	3,600	553	4,831	815	89	-	183	3,950	614	20,771
	Grad.	64	1	12	-	454	323	769	123	547	189	31	-	11	360	453	3,327
Estimated number of full-time students who could be taught with additional staff	Under-grad	8,064	2,451	3,614	873	25,606	23,407	26,778	5,854	38,217	4,921	3,606	616	2,786	24,215	4,906	176,892
	Grad.	362	323	232	89	1,165	1,113	1,066	274	1,598	280	179	65	94	317	440	7,597
Estimated number of part-time and evening students who could be taught with additional staff	Under-grad	1,581	283	458	147	4,840	4,230	5,412	1,444	6,960	1,580	966	206	411	8,836	1,191	38,545
	Grad.	64	1	18	25	534	444	993	165	537	226	86	-	20	460	655	4,324
Additional staff members needed- - -		69	31	69	7	221	296	331	66	406	61	34	2	27	136	210	1,974

/1\ These figures are derived from returns on a questionnaire distributed by the National Roster of Scientific and Specialized Personnel to 172 engineering schools. Replies were received from 166 institutions, including the University of Alaska, the University of Hawaii, and the University of Puerto Rico.

TIME

By JOHN ANDERSON

Professor of Civil Engineering, The Citadel

"Time goes you say? Ah no! Alas, Time stays, we go."
—Austin Dobson.

(The reader is to suppose that having partaken of a very satisfying mid-day repast he has seated himself in an obscure corner of the astronomy class room. An aura of unreality seems to pervade the atmosphere.)

Good afternoon, gentlemen! The question today is "What is Time?" You have the answer? "Time is"—yes? yes?—"is well —ah—just time." Perhaps so, but that seems to me like a vicious circle that didn't get started! Probably there isn't any such thing as time. One of my learned confreres has said "of time, as of space, we cannot assert a real existence. It is not in things, but in our mode of perceiving them." Tom Carlyle writes in "Sartor Resartus" of the "two quite mysterious world embracing phantasms, time and space." We live only in the present and what these gentlemen are trying to say is that time is just a state of mind. It is and it isn't. Let's see what help we can get from our old standby, the Dictionary. We find "Standard" defining time as "the general idea, relation or fact of continuous or successive existence." "Oxford" (quite a good one; it takes about five feet of space on our library shelf) says it is "a limited stretch or space of existence." "International" tells us, with what appears to be an attempt at a joke, it is "that in which events are distinguished with reference to before and after." Now do you know what time is? It seems to me that all those dictionaries are just shuffling words and they might just as well have stopped with my young friend's "Time is time."

But why bother with a definition? It is perhaps safer to assume that you know what I am talking about. At least we all appreciate that certain events like Fourth of July and Christmas are not celebrated on the same day. It is also quite plain that there is a greater hiatus between supper and breakfast than between breakfast and dinner. Our senses (and the radio) tell us that "time marches on" but we are pretty poor judges when it comes to telling just how much has gone by. If you went to church on Sunday you were probably willing to swear on the customary stack of Bibles

that the parson preached for an hour. Actually it was only nineteen minutes and the preacher was wondering how his twenty minutes got by before he said half of what he had in mind!

Measurement of any sort requires that we use a unit. Often we have a choice of units. Distance can be measured along a road in feet, or in yards, or in miles. It makes no great difference because everybody knows "3 feet one yard, 1760 yards one mile." If time is to be measured there are three units we could use, the DAY, the MONTH, or the YEAR. Unfortunately, unlike the foot, yard, and mile, these three units are incommensurable. This sesquipedalian word is just a fancy way of saying that there are not an even number of days in a year, or in a month, nor can you fit an exact number of months into a year. Now this is just one of "those things" but it has given rise to centuries of political, scientific and ecclesiastical squabbling.

The DAY has been selected by scientists as the unit, since it seems to be the easiest one to use. The Professor of Physics across the hall has been telling you that the SECOND is the unit of time, but if you pin him down he will have to admit that he gets his second by dividing a day into 86,400 parts.

But whether the unit be a day, hour, minute, or second, measuring time seems so little of a job that we leave it to a mere machine. When we want to know what we call THE TIME (which is something we find even more intangible than plain TIME when we try to define it) we glance casually at a watch or a clock.

But clocks and watches have a way of stopping at the most inconvenient moments. What do you do when your watch stops? Most likely you ask your neighbor for "the time." Thereupon he consults his timepiece, scratches his ear, and says, "Well, my watch was three minutes slow yesterday and five minutes fast last Thursday, so I guess it's about three thirty." As this seems slightly indefinite perhaps you go down town to the Western Union office and get the RIGHT time.

Now how does Western Union know that their time IS the correct time? The neat little signs on their clocks say they give "Naval Observatory Time Hourly." There is a slight (perhaps pardonable) inexactitude in this statement, but at least the signs seem to divulge the source of correct time—the Naval Observatory.

Let us suppose we are keen enough in our search for this elusive quantity and take ourselves to Washington to investigate its source. Armed with the necessary authority (these days it takes something better than an A- 1- J priority to get past the gate) we approach the doorman and ask "How do you know the time?" This seems to be an easy one. He replies, "By our clock; that one over there. It's the one that sends out all the time signals, except when we are

using its twin brother next to it." "Quite so," we say, "but how do you know that your clock is right?" "Oh! by comparing it with our master clocks. As a matter of fact it is seldom ever exactly right." The latter part of this answer is a bit disturbing, but we see a gleam of light. "A master clock? Where is it?" And then we discover that Naval Observatory officials are quite pessimistic on the subject of clocks—it is not one master clock but four such creatures which they keep in solitary confinement in a veritable dungeon. Down in the nether regions of the observatory we find these clock aristocrats, each in its own airtight case and resting on its own solid masonry pedestal. The vault in which they repose is double-walled, air-conditioned, and triple-doored. Access to it is more difficult than to the gold depository at Fort Knox. It is hard to believe that such clocks exist, never touched by hand, wound automatically and never varying as much as a second in five years.

We view these marvels with awe, feeling that at last we have discovered the place where the RIGHT TIME is to be found. It is only when we express this thought that we discover the real depths of Naval Observatory pessimism. We are astounded to find that they have so little faith in these wonderful clocks they have to check them every day. While this does seem like a wise precaution it presents another question which we immdiately voice. "What do you check with? Whose clock DO you trust?" The doorman sadly shakes his head and calls in the aid of a gentlemen with long white whiskers who is passing. "Ah! Father Time! Chronos! how stupid not to think of it!" we say. "Not at all," says the doorman. "This is just one of our astronomers who has been trying to find the time ever since Cleveland was President. I am sure he can tell you what you want to know."

From the astronomer's explanation it seems that to keep time we need some sort of moving object whose motion is steady, unvarying and perpetual. Furthermore it must be of such character that we can easily observe its movement. The only object complying with these specifications seems to be our earth. Recollecting your geography you will remember that the earth is a spheroidal body which rotates on its polar axis once a day and keeps on doing this, day after day, saecula saeculorum, with a regularity that cannot be equalled by any man made mechanism.

As a consequence of the earth's rotation, just as a person on a train sees the landscape rushing by, we see the stars, the sun and the moon, the planets and all the heavenly host apparently traveling westward. If our eyes were adapted to seeing these bodies in daylight the whole celestial pageant would be seen repeated daily, always returning exactly on schedule.

Although we were taught that the earth moves and the stars are fixed, we prefer to believe the evidence of our senses and we say that the sun rises and sets, and together with the stars, travels from east to west, completely round the earth once a day. Even the astronomer finds this erroneous conception so much more convenient than the real state of affairs that he adopts it and speaks of the stars passing around the earth once a day.

Thus it is only necessary to fix our attention on a particular star, watch it as it passes by and wait until it comes around again. Then a DAY has elapsed. If we note the time of its first passage on our clock and that of its second, and our clock shows exactly the same time (or rather, exactly 24-hours difference), the clock is correctly adjusted and performing perfectly.

Of course, to see the star it has to be viewed at night (which is a bit of a nuisance) so a happy thought occurs to us—why not use the sun? So far as we can see, it behaves quite in the same way as the stars, circling round the earth once a day. It seems worth trying, but as soon as we put the idea into practice we find that the clock which had been running perfectly must have suffered a sunstroke! It seems to be gaining, at first slowly, then more rapidly, then slowly, never able to settle down to a steady rate, but always gaining. If we have enough patience to continue the experiment for a year, we will find that our clock has managed to steal ahead a whole twenty-four hour day. No amount of tinkering with the clock seems to do any good. We do manage to cure it of gaining a whole day in a year, but it just will not keep step with the sun. We are almost forced to conclude that there is something wrong with the sun. Remembering what happened to Galileo when he imputed certain imperfections to that great luminary we do a little investigating before committing ourselves. We discover that it is not the sun which is at fault, but the earth. Not only does the earth rotate on its axis daily but it also revolves round the sun once a year. This would not be so bad if it didn't insist on going a little slower sometimes than others. The small boy's idea that the days drag at Christmas is literally true! Gravitation seems to be to blame for this phenomenon and it has all been explained very nicely by Sir Isaac Newton—you probably won't mind if I skip the explanation. This irregularity of the earth's motion about the sun only partly accounts for the vagaries of our clock. To keep the record straight we should mention the "obliquity of the ecliptic" and the "precession of the equinoxes" but these are things reserved for the consideration of those who have reached a higher standing in the lodge.

But how do we explain the fact that the clock got ahead of the sun a whole day? With your kind assistance we will put on a little

demonstration. The gentleman in the center of the room, Mr. Jones, will you please stand up? Thank you. Now, that gentleman in the back row, Mr. Brown, will you stand please? Mr. Jones face Mr. Brown. Now Mr. Brown will you make a little journey around the outside of the room? That is right, go round toward the east, and please rotate on your axis! To the east of course. Quite good. You see you are the earth. Mr. Jones will count the number of times you face him, I will count the number of times you face the front of the room. Hold on to the wall if you feel dizzy. Splendid, that completes the circuit, and I count 15. Mr. Jones? 14. Thank you. You see now that the earth has seen the sun (that's Mr. Jones) 14 times, and the star (that's me) 15 times. That's why a clock regulated by the stars counts off 366 days while a sun clock counts only 365.

Now we ARE in trouble, either use the constant stars and try to live 366 days in a year or use the erratic sun and get 365 days of all sorts of lengths! It seems a hopeless situation but our wily astronomer has fixed the whole thing in a most satisfactory way. He INVENTED a sun of his own. He christened it the MEAN SUN, which is hardly fair since it is not a bit mean but very tractable and accommodating. Having evolved the creature the astronomer gave it the following instructions: "Begin on the mark with the real sun, and travel round the earth once a day, but pay no further attention to that eccentric object. You must watch the speedometer and keep to the same speed without varying a jot, and *stick to the straight and narrow path,* I mean the equator. But remember, this is not a race. You must arrive at the starting place one year later at exactly the same instant as the real sun. You will both have made 365¼ trips round the earth, but your trips will all have been of the same length. I will watch when you cross my meridian and that instant will be called MEAN NOON; the time it takes you to go around once will be a MEAN DAY. For convenience I'll make the day begin at midnight when I can't see you at all."

What a lovely scheme! But what a lunatic the astronomer is! How can he watch a non-existent figment of his imagination? He even admits himself that if it did exist, it couldn't possibly be seen at the most important instant when the day begins. Just another crazy idea!

But the astronomer's imagination has been a little bit busier than we thought—he has it all figured out. A star-clock would count 366¼ days in a year, one day too much according to our ideas. In short, it runs fast one day a year, 86,400 seconds, or just about 3 minutes and 56 seconds a day. "So, the matter is quite simple," he says, "I regulate my own clock by the stars and for ordinary people I keep another one adjusted to lose 3 minutes

56 seconds every day as compared to mine. They don't know how I do it. I show them the clock which is wrong and tell them that is THE TIME." So the astronomers the world over keep time, each for himself, by watching the stars, but fool the civilian population by pretending to do it by the sun.

The astronomers seem to have very convincing ways and people have accepted them as the arbiters of time. It appears that all that is necessary is to select your astronomer and tell him to go to work. Not every one is fortunate enough to have such a professional man at his disposal. Inquiring persons soon found out that there was no great trick to this time telling business and set up little time factories of their own. In time past the inhabitants of many a town have eagerly waited watch in hand for the sound of Grandfather William's pistol to let them know that it was high noon.

This way of telling time is essentially individual, every man for himself. While it worked pretty well in the horse and buggy days the advent of railroads, telegraphs and other means of rapid intercommunication soon disclosed serious inconveniences in this individualistic scheme. The railroads found it impossible to regulate their train schedules to suit a dozen or more different ideas as to time, so each railroad adopted a "standard" of its own. This resulted in some strange things. For instance, the clock outside the station in Paris was five minutes ahead of the one inside—and both were right. This would seem to have some compensation. The perturbed traveler rushing into the station fearing that his train had gone must have been gratified to find he had five minutes to spare. But generally patrons were confronted with the necessity of doing some tricky arithmetic to know just when to be at the station. Some railroad companies published information supposed to help the travelers—like this: "P. D. & Q. R.R. time in Podunk is six minutes ahead of Podunk local time and five minutes later than W. P. & X. R.R. time in that city. Podunk local time is 32 minutes behind Zoomville time which is the standard time for the K. Y. D. U. R.R." At all events, "daylight saving war time" could have no terrors for one brought up on that system.

This quite intolerable situation was finally remedied by depriving individuals of another inalienable right and establishing a single clock to keep time for all. This clock is the one at Greenwich, England. Americans were largely responsible for the selection of Greenwich. Apart from a seeming lack of patriotism in this choice, if one considers that when it is noon at Greenwich it is just 6:37 A.M. here in Podunk, a condition due to the fact that the sun can't be at both places at the same time. Nobody in Podunk is going to believe that it is 12 noon at 6:37 in the morning. So we compromise

by agreeing to call Podunk time 7:00 A.M. and designate it "Eastern Standard Time" except that now we call it 6:00 A.M. and say it is "War Time." We never make up our minds about anything.

Having settled this rather ticklish question we turn the job of watching the hypothetical mean sun back to the astronomers and the matter of keeping us informed to the radio announcers. The astronomers have always believed in minding their own affairs and have retired into the limbo of anonymity. They are such modest people they never seem to resent the calm assurance with which the honey voiced announcer steals their thunder when he suavely informs us "3:00 P.M. Eastern War Time, courtesy of the Bull-allover Watch Company."

Time is up did you say? I am sorry, my watch has stopped. Thank you! Good Afternoon!

(And so you wake up, wondering whether it was the apple pie or that stick you put in the demitasse.)

WHAT MATHEMATICAL COLLEGE TRAINING INDUSTRY EXPECTS FROM YOUNG ENGINEERS *

By A. R. STEVENSON, JR.

Staff Assistant to Vice President, General Electric Co.

When Professor Dawes asked me to give this talk, I hesitated to accept because I had never taught mathematics in college, and it is always risky to try to give advice in a field where one has no experience. Professor Dawes explained, however, that the industries are the customers who need the young engineers, and that the college professors would like industry to give its reaction to the qualifications of the men that they are obtaining from the colleges.

Of course, we all know that industry has certain problems to solve. Perhaps they could be divided into two classes: (*a*) synthetic problems requiring ingenuity, and (*b*) analytical problems requiring methods of analysis which are largely mathematical.

At first glance, one might say that the mathematical courses have nothing to do with the training of men for the synthetic, intuitive, inventive, creative type of engineering. There are, of course, a great many inventors who are not mathematical. On the other hand, it has always been said that mathematics develops the imagination, and of course imagination is necessary for invention.

Perhaps if in mathematics courses a little more emphasis were placed on developing ingenuity, the sometimes expressed idea that mathematics deadens the creative faculties might be refuted.

From the very beginning of mathematical training in the grade schools, the pupils should be encouraged to create their own mathematics. A child under the guidance of the teacher should discover for himself that $2+2=4$ by grouping four pieces in two groups and by counting each group separately, the group as a whole, etc. Perhaps a good deal of arithmetic is too complicated to be understood by young children and so should be postponed until it can be done in a more understandable way by algebra.

When I was in grade school, I remember an arithmetic problem which I could not understand. My father asked me what it was I was trying to find out. I told him. He said: "Let's call that quantity 'X'." With this suggestion, it was clear as crystal to

* Presented at the New England Section Meeting, Wentworth Institute, October 17, 1942.

me as to how to proceed. I turned in a solution but the teacher did not like it because I had used an algebraic rather than an arithmetical method. While I did not know that I had used algebra, this suggestion had led me to a complete comprehension and a straight forward solution.

There is a story about the famous French scientist, Pascal, which goes as follows:

"Pascal while still very young asked his father to tell him the object of geometry. His father, who did not want him to study too much and therefore did not want to arouse his curiosity, gave him a vague definition. He said: 'Geometry is the art of constructing regular figures and finding their measure and learning the relations of their parts.' This was a sufficient basis for Pascal to develop, all alone, the thirty-one first theorems of Euclid."

Mathematics is a chain that is not much stronger than its weakest link. If one really understands arithmetic, algebra is easy; if one really understands algebra, trigonometry is easy. Students should be warned against committing to memory trigonometric equations. If one really understands the subject, one can create many trigonometric equations by simply referring to the fundamental diagrams inscribed in a circle.

Someone may say: "I thought you were going to talk about mathematics in college, and here you are talking about mathematics in grade school and high school." Here is my reason. When I was a senior in an engineering college, one of the professors found that the class was having difficulty with certain engineering problems which made him doubt how much we knew about plane geometry and trigonometry. An examination was given and only five fellows passed plane geometry and only two passed trigonometry. Perhaps one can solve certain simple engineering problems without understanding these subjects, but one cannot develop his creative faculties by the solutions of engineering problems unless he really understands these fundamental subjects.

Descriptive geometry, if properly taught, should develop the visual imagination, and visual imagination is obviously of great help in inventing mechanical arrangements. The value of descriptive geometry depends, however, on how it is taught. I can recall a descriptive geometry examination where the problem was to develop the cross section which a plane made in cutting a hyperbolic paraboloid at an angle; I got the right answer, but a mark of only 80 per cent. In explaining this the professor said: "You did not use the method I lectured on." In other words, his emphasis was on remembering what he taught me rather than in developing my own method. A more thorough course in descrip-

tive geometry including mechanical perspective and shadows would be beneficial in developing visual imagination.

Most students would probably object to a statement that calculus is fed with a silver spoon. Nevertheless, students are not made to struggle, to create it for themselves. They are often given solutions and perhaps asked to prove them, where they should be led to discover the solutions for themselves. For instance, quite early in the study of calculus, they are told that a convenient base for logarithms is $e = 2.7183$ which, in spite of its odd character, is more convenient for certain mathematical purposes than the more ordinary base 10. Wouldn't it be immensely better if the student could be taught to discover for himself the convenience of this particular base, rather than to take the teacher's or the text book's word for it?

A good many undergraduate college courses include differential and integral calculus, but do not include any differential equations. Calculus is not usable on any but the most simple engineering problems unless one knows differential equations. I think it is because many engineers, not having learned differential equations, do not use calculus and consequently forget the little they have learned. Differential equations can be taught very simply as a series of ingenious tricks which as far as possible the student should be encouraged to invent for himself. For engineering purposes, it is sufficient to acknowledge that if the differential equation represents an engineering problem, there is a solution. The correctness of the solution should simply depend on whether it will fit the differential equation and the boundary conditions.

In a few colleges, there are courses in the application of mathematics to problems. This seems like a very good idea. After all, from an engineering point of view, mathematics is a tool. Examining this analogy further, it is obvious that one cannot learn much about tools without using them. If one has a problem to solve and then learns the mathematics with which to solve it, the mathematics will become a tool which can be usefully applied to other problems later.

In studying differential equations in college, it is stated that the singular solution of the differential equation gives the envelope of a family of curves. In later life, I wanted the equation for the envelope of a family of curves and I remembered that the singular solution should give the equation of the envelope. In my old differential equation books, however, this mathematical method was not sufficiently illustrated by practical problems to make it particularly applicable to the case in hand. In the end I obtained the desired equation by some much longer and laborious method which was really understood.

All through courses in mathematics, the emphasis should be placed on understanding the theory and being able to apply the theory to the solution of practical problems.

My younger brother was very much interested in mathematics and did very well in high school and college until he took a course where one of the problems was somewhat as follows: "Three horses, which were grazing in a field, ran straight for the barn when the farmer opened the door but they stopped en route when he closed it. Prove that the three lines determined by the positions of the horses at the start intersect the three corresponding lines determined by their positions when they stopped in three points which lie in one straight line." The statement of this problem is probably mixed because I never studied that particular branch of mathematics and hope I'll never have to. My brother was so disgusted that he went before the faculty to get permission to drop the course and changed to something more useful.

The combination of engineering and the liberal arts in the same university is good. The engineers gain a great deal from association with their academic friends and, conversely, the academic students cannot become all-round cultured individuals without coming into some contact with the materialistic realities of the universe with which engineers deal. Wherever engineering and the liberal arts are combined in the same college, it is probably a good idea if the engineering and the academic students can mix in the same classes in physics, mathematics, English, etc. But if this is done, the mathematics professors must be broad-gauged men and not narrow-minded specialists who believe that the perfect idealism of mathematics will be soiled if it is in any way degraded toward the utilitarian level.

Some years ago I was on an advisory committee to the Mathematics Department of the Rensselaer Polytechnic Institute. We spent the whole day discussing the problems of the Mathematics Department. President Hotchkiss had invited members of the Physics and Engineering Departments to attend the meeting which was also attended by members of the Board of Trustees and two or three outsiders like myself. The object was to secure coöperation between these departments so that the mathematics department, instead of using impractical problems like the one about the horses, would illustrate their mathematical theories with applications to physical and engineering problems. On the other hand, the physics and engineering professors would make full use of mathematical tools in solving their scientific problems. The general feeling of comradeship and coördination between these three departments was very delightful. Meetings of this kind would be

profitable in other colleges in securing coöperation between these three related departments.

Of course, the whole of education should be integrated. The proper use of the English language should not be limited to courses in English. The mathematics, physics, and engineering professors should insist on proper presentation both written and oral in their classes.

The college course is already so full that, according to President Doherty of Carnegie Institute of Technology, the students do not have time to understand more than half of what they learn. The other half they take on the authority of the teachers or the text book without ever really understanding it. This is a pernicious habit which should be avoided. It would be better to learn half as much and really understand it.

Everyone is beginning to believe that engineers should be given a broad education including plenty of English, economics, and the social sciences. If these liberal subjects are to be included in the engineering course, something must be left out. Courses must be cut to the bare fundamentals, thus leaving time so that these fundamentals can really be understood. Handbook methods of design should be omitted from the college course because they prevent a proper attention to fundamentals.

Recently, some juniors spending the summer working for our Company were given an examination which many of them flunked. They could have passed it if they had only applied the fundamental law that Force = Mass × Acceleration. When the failure to apply this law was pointed out to them, some of the boys took the indignant attitude that they had learned that formula in their freshman year and could not be expected to remember it now that they were dignified juniors. Their fundamental knowledge was overlaid with too much else.

It will be necessary to omit from the undergraduate engineering course specialized subjects such as Heaviside's method of solving differential equations, vector analysis, tensor analysis, special courses in circuit analysis, etc., all of which are valuable but should be postponed to post-graduate years either in college or in industry for those with special aptitudes along these lines.

The colleges should teach the fundamentals, and it is the responsibility of industry to put the recent graduates through an apprentice type of education which will furnish the proper transition. To quote from a former paper:

"The age old idea of apprenticeship must be revivified in order to form a better connection between what is learned in school and its application to real life.

"Industry should not attempt to compete with the colleges in teaching the educational fundamentals. Any attempt to do this would be likely to lead to inbreeding within each industry, resulting from localized recruiting and narrow specialization. But while giving the young men their first taste of experience, industry can furnish the educational connecting links which are necessary for the wide application of education to the solution of practical problems."

It would be perfectly logical for any professor to comment that there are not many Pascals in the world and therefore the system of developing ingenuity by making the students work out their own mathematical theories is not practical. Certainly, it is not practical in an educational system which is designed for the average and backward students with very little thought given to allowing a few exceptional individuals to develop their individual talent.

Of course, we want to educate the average man in this democratic country, but we should also give considerable thought to including in our educational system avenues by which young men with exceptional possibilities can be trained to be exceptional men.

A look at history will indicate that in every field of human endeavor the world has been greatly benefited by a few such individuals. When we think of the hundreds of millions of people in the world, the percentage of inventors, scientists, and leaders is extremely small; yet this small handful of people have given jobs to multitudes and have raised the standard of living for almost everyone.

Wickenden, in a recent article, stated:

"Every engineer knows that permanent gains in wealth and leisure are the by-products of rising efficiency and cannot be created by government subsidy; that the way to cure unemployment is to create more jobs through research, thrift, and enterprise, by development of new products, by creating new industries, and by translating technical advances into reduced prices and wider markets. One quarter of all our employment today is said to be in industries which did not exist before 1880."

If we are going to go on in the postwar era creating employment and raising the standard of living, we must learn how to develop these exceptional individuals to the fullest extent.

EDUCATIONAL REQUIREMENTS FOR AIRLINE TRANSPORTATION ENGINEERING

By GEORGE H. TWENEY

University of Detroit

Airline transportation engineering is a branch of the Aeronautical Engineering profession which has come into prominence only within the past few years. Prior to 1935, any work done around an airline even remotely savoring of engineering technicalities was purely coincidental, but today, some of the larger airlines are maintaining engineering staffs composed of as many as one hundred technical men. This, of course, is a small staff compared to the commercial manufacturing corporations with their engineering departments numbering as high as 1200 engineering men.

However, for an airline even to have a separate engineering department is a relatively recent development. It was not until the spring of 1935, when Pan American Airways hired a few engineering graduates, that technically trained men were given positions in which they could utilize their technical ability around an airline. Any engineers who were employed by airlines prior to that date were either hired in a purely clerical capacity, or perhaps because they held pilots' licenses, and could fill some of the flying positions.

An airline transportation engineer, so called, is a rather hybrid sort of individual; he must be an engineering "jack of all trades," and strangely enough, master of them all at the same time. There is, as yet, no university in the country which offers a full time engineering curriculum leading to a degree in Airline Transportation, although there are numerous institutions which offer alternate courses, and separate subjects covering various phases of airline operation.

A young Aeronautical graduate who decides to go into airline engineering will find that his knowledge of theoretical aerodynamics, wind tunnel procedures, and like subjects of a highly theoretical nature will not stand him in very good stead, and that from the day he first starts to work, he really has to start to learn. If he is assigned to the maintenance engineering group, and the Instrument shop presents him with a stubborn automatic pilot which refuses to be calibrated, he must solve the difficulty almost immediately. It has been the author's experience too, that they will not bring up these knotty problems until the night before the par-

ticular airplane is posted for schedule. This then means a lot of burning of the midnight oil, for the young engineer to learn something about an automatic pilot. Search as he might, he cannot seem to find anything in his class notes which even remotely resembles the hydraulic diagram of a modern automatic pilot, and he is left to his own resources with a collection of hard-to-understand service manuals and manufacturers' booklets.

But this is only one specific instance of the type of problem which an airline engineer might be called upon to solve.

Strictly speaking, the design aspects of airline engineering are rather limited, the greater portion of their work being of a maintenance and operating nature.

However, an engineer may be called on to do a piece of structural analysis, or develop some performance and range curves for a particular airplane over a particular route. Hence, he must keep his technical knowledge at hand continuously, and at the same time making himself familiar with the myriad mechanical problems which are always presenting themselves.

This type of airline engineering has to do principally with maintenance procedures. There are, however, other departments of an airline which require the services of a technically trained man. The Operations Departments of most large airlines maintain a man called an Operations Engineer. His job is to handle all problems of an operating character, including pilot and flight personnel training, to hold classroom sessions in various technical subjects with which all flight men should have a conversant knowledge, and to develop various types of new operating equipment. An Operations Engineer is almost invariably an aeronautical graduate, whose experience has been tempered with several years service doing maintenance and general engineering.

The advent of the large airplane of the Clipper and Stratoclipper types, is bringing into the foreground another type of airline engineer who is called a Flight Engineer. These airplanes are assuming such proportions that it requires the services of a technically trained man to handle all the engine and power instruments, thus leaving the pilots free to concentrate on the actual flying and navigation. The ultimate in this type of engineering is exemplified in such airplanes as the Boeing B-314 Clipper ships. Of course, this man does a large amount of flying, and his job is more of a mechanical nature than it is technical. He must be entirely familar with the engines and all accessories of the airplane, so that he can perform dependable trouble-shooting, and then do the necessary repairs on hand. Then too, it is his responsibility to follow fuel and oil consumption, and on his shoulders rests the responsibility for deciding whether or not an airplane shall continue on or

turn back on a particular trip when fuel consumption may be running ahead of schedule.

There are other types of specialist engineers which various airlines employ. For example, the Aerodynamics Engineer occupies a fairly important place in the scheme of airline operation. It is his job to prepare all performance and range charts for the various runs over which the airline operates. If the engines or propellers should be changed on some of the transport models, he must prepare new performance charts showing the changes in airplane performance or specific fuel consumption. Then too, a very important phase of his duties is taking care of all engineering test flights. In this connection he must work in close coöperation with the inspection department. If certain changes, such as instrument changes, are made on an airplane during a regular maintenance procedure, it may become necessary for the engineering department to order a test flight before it can pass the changes, and certify the airplane is ready for schedule flights. In this way, the Aerodynamics engineer may do a large amount of interesting and variable test-flying.

In addition, the Radio and Meteorology, and the Inspection Departments may hire men with an engineering background. In most cases these positions are more or less specialized in nature, and will require men who have been trained in some one of the more general phases of airline transportation engineering.

At the University of Detroit, the Aeronautics Department does not attempt to give a specialized course in Airline Transportation Engineering. In the Senior year of the regular Aeronautical Engineering course, we give the student a choice between a Technical or an Industrial Option. In either election, the student will take a one-semester course in the subject Airports and Airways. However, if the student plans on entering some phase of airline operations, we recommend that he elect the Industrial Option, where in addition to the Airways course, he will receive additional training in such subjects as Engineering Law, Business Administration, and Personnel Management. In this way, the student will be better equipped to take such generalized engineering positions as the Airlines offer, where he will not be required to do such rigorous technical work as he would in a purely engineering position involving research or design.

The course in Airports and Airways is a short introduction to the economics of airline operation, and the organizational characteristics of a modern airline. In the opening phases of the course, we give the mathematical development of the equations for calculating the speed-made-good for various types of transports over various lengths of runs, and flying at various altitudes. There are

two equations involved, one for the calculation of scheduled speed made good at low altitudes, and the other for the scheduled speed made good at high altitudes.

The derivation of these two equations involves a fairly large amount of time, since a thorough study of effects of flight at various altitudes, effects of maximum cruising speed of an airplane on scheduled speed, and effects of factors affecting speed made good such as ground manoeuvering time, etc., is made during the development of the equations.

Then follows an analysis of the organization of a modern airline along both the functional and straight-line systems of organization. The set-up for a typical domestic airline, and a typical international airline are studied in detail.

The course is concluded by a thorough analysis of the economic features of a modern airline. The calculation of Direct Operating Charges and Fixed Charges for a typical airline are worked out in class in great detail, and the student follows along with a similar home problem in complete detail which becomes due at the end of the course. Charts showing the growth of airline operations through the past years are drawn, analyzing the increases in passenger miles flown, pounds of mail carried, and pounds of express carried.

This year, the author inaugurated a particular type of problem for this class, which, although only assigned once to date, seems to have fulfilled expectations even more than was originally hoped. At the midpoint of the course, the student is assigned the problem of laying out and establishing an airline over a given route, which this year was from Dayton Ohio, to Nome Alaska. The only stipulated conditions are that the route must be covered as efficiently as possible, in the least time as possible, with a maximum amount of allowable payload to be carried.

The student is required to select a suitable airplane for the route he wishes to fly, compute all the speeds made good for the various legs of the route as he lays it out, compute fuel consumptions, payloads, flight times and altitudes, and lay out a route map for the entire distance showing mileages, etc.

Some remarkably fine reports were turned in on this assignment. Most of the students showed that they had acquired the faculty of being able to efficiently analyse many of the operating problems connected with a modern airline, and speaking from past airline experience, the author knows that several of these reports were so complete in every detail, even including meteorological considerations, that they could be taken as the initial step in the actual establishment of such an airline.

The author feels that the solution of this problem in as much

detail as done by the majority of the students, thoroughly demonstrated more of the actual problems involved in airline transportation engineering than could have been discussed in class in the period of a whole month.

It will be noticed that no attempt is made to teach the embryo airline engineer anything about the thousands of maintenance problems which he will undoubtedly run across. These can only be learned through experience. If, when associating himself with an airline, the young graduate would request a six months training period in the airline's maintenance shops, this would be the very best type of training that he could possibly get. As a matter of fact, several of the larger airlines are actually making this a requirement of their new engineers, but the majority are still putting the man on the job as soon as possible.

If the young graduate possesses the time and the necessary wherewithal, he could very profitably spend a year in one of the better trade schools such as the Boeing School of Aeronautics, and take their course in Airline Maintenance and Operations. At the conclusion of this type of a course, and backed by his engineering training, he would possess the necessary qualifications for becoming an A-1 Airline Transportation Engineer. From that point on, it would be entirely up to him, as to the amount of progress he could actually make.

The tendency for a young engineer to choose Airline Transportation Engineering as a career will undoubtedly decrease during the next few years, or at least as long as world conditions exist as they are at the present time. The unprecedented demand for aeronautical engineers in the manufacturing and National Defense programs has created a scarcity of young men with the required training, and hence there are practically none available for the airlines. The military manufacturers are able to offer so much more attractive proposals than the airlines, that this, too is tending to draw all available men into the industry.

However, with the cessation of preparedness programs, the world will witness such an expansion of travel by air as it has never experienced in all its history. Such things as the carrying of all first class mail by air, the inauguration of high-speed express routes, and the tremendous expansion in feeder-line transport will give us air networks in this country not even equalled by the mushroom growth of the railroads in their heydey. Then will come the real opportunities for the Airline Transportation Engineer. There will be unlimited opportunities in both domestic and international air transport, and with the facilities and trained man-power we already have at our disposal, the United States will lead the world in quality and volume of Air Transport.

FOREIGN LANGUAGES IN A SCHOOL OF ENGINEERING

By D. P. KRYNINE

Research Associate in Soil Mechanics, Yale University

The object of this article is twofold: (*a*) to give a brief outline of the work done at the present time in the province of teaching foreign languages to engineering students, and (*b*) to advance some views as to how this work should be done, if at all, during the war and in the post-war period. These views are the writer's and are submitted for possible criticism and discussion.

The undergraduate curriculum for engineering students does not always contain foreign languages. Graduate students who are candidates for the doctor's degree generally have to pass an examination in both German and French, one year before the presentation of the dissertation. Graduate students working for the master's degree are generally excused from foreign languages.

Graduate students who take the examination in foreign languages are supposed to acquire the knowledge of those languages by themselves. In some universities the German and French departments organize foreign language courses for engineering students. Sometimes students take private lessons mostly from teachers having no engineering preparation and unfamiliar with engineering terms and interests. In some instances women teachers are preferred on the theory that women are more talkative than men, and during a short lesson many subjects may be touched. Others prefer men teachers, since in their eventual engineering and scientific contacts they will deal mostly with men, and they want to hear how men speak a given language. In the belief of the writer, there is a kernel of sense in the latter opinion, since, after all, men and women do not speak exactly in the same way.

As to the requirements of the examination itself, they are also different. The examination may be oral, or written, or both. Generally, the student is given a foreign book or article and is required to read it in English without having to read it aloud in the original tongue. In other words, the examiner does not care what kind of accent the student has in the given language. Besides technical matters, the student is sometimes required to translate novels, short stories, or similar material. The use of a dictionary is sometimes permitted, sometimes—and this is in rare occasions—the dictionary

is taboo. Personally, the writer does not see why a reasonable use of the dictionary should signify an unsatisfactory knowledge of a language. Do persons who possess excellent command of English never consult Webster? Technical and scientific material of mathematical character, such as the theory of elasticity or fluid mechanics should be read, of course, without dictionary.

The writer has observed some cases when, two or three years after passing his or her examination in foreign languages, the student (now Ph.D.) had but a very remote idea of these languages These observations were outside of a school of engineering; but of course, the same situation may occur with engineering students too.

General Statements

Practice of examinations and teaching in foreign languages for graduate students in the Department of Civil Engineering at Yale is described hereafter. It should be understood that the work described represents the writer's own experiment rather than a definite policy of the Department. The writer formulated for himself the following statements:

Statement 1

For making a good translation from a foreign language, for instance from German into English, three things are necessary, and in the following order of importance: (*a*) A thorough knowledge of a given speciality, and particularly a good understanding of the subject-matter of the given article; (*b*) perfect command of written English; (*c*) satisfactory knowledge of German. Thus an educated German girl speaking good English cannot translate an article in organic chemistry, if she never studied this science. Again, an American engineer, of a given speciality knowing some German, possibly will prepare a better translation from German into English than a German engineer, of the same speciality, knowing some English.

It follows from this statement that good formal knowledge of a foreign language is not very necessary for an engineer if he does not intend to go abroad for a long period of time. He does not need to know well all the exceptions in the grammar; but, if he sees a new issue of a foreign technical periodical, he must be at home there and must be able to understand what the authors are talking about and to choose an interesting article, if any, for himself. He must be able to translate that interesting article of his using a dictionary. That is all he needs. This statement may sound like heresy to the faculty members of German and French departments; the writer, however, believes that it is correct.

Statement 2

In teaching a foreign language, emphasis should be laid on the study of ideas, and not on the study of words. The acquisition of a certain vocabulary is, of course, an unavoidable evil. It should not be forgotten, however, that the time used in memorizing words is an unpleasant duty for a grown-up person and is generally considered as time lost. Furthermore, as stated above, words evaporate very easily from the mind; whereas, this is not so general in the case of ideas. Since we are dealing with engineering students these ideas should be of technical character. The writer believes that the student's work must lead him to the answers to the following questions:

(*a*) Is civil engineering more (or less) advanced in that country than in America: in what branches: what is worthwhile to study in that country?
(*b*) Do engineers in that country know what is being done in America? Do they follow the American technical literature?
(*c*) What do engineers of that country think about American work in civil engineering? What have we to think about them?
(*d*) Who are the outstanding civil engineers in that country? What did they do?
(e) What is the past of civil engineering in that country? (Some engineering history.)

Statement 3

In teaching foreign languages for engineers, emphasis should be laid on the reading of the current periodical literature and not on the reading of books. Possibly the material, which may be found in outstanding foreign technical books, is already included in the corresponding graduate courses given in the school. This is not true of the latest issues of periodicals. Furthermore, to read a book requires much time which may be usefully spent in getting familiar with several periodicals. Finally, periodicals reflect the actual cross section of the technical life in a given country whereas the best book generally deals with one side of it only.

Organization of the Work

After some trials, the following procedure has been developed at Yale. To start the work in the Department of Civil Engineering some little knowledge of the language is required as a prerequisite, since it is obvious that the Department cannot teach such things as reading or elementary grammar. But nobody is permitted to take an examination in foreign languages if he is not

familiar with the periodical technical literature in the given language and with the technical life of the corresponding country. The Department takes care of this work.

As soon as the instructor determines the degree of knowledge of a new student in the given language, he gives him a written assignment based on the student's preparation. Generally, the first assignment is concerned with the cover of a periodical, its title, where and by whom it is published, its table of contents, titles of some articles. The student is advised to have a wordbook, to write down all the new words and to learn them. The next time he comes to see the instructor, the latter checks his work, and hands him assignment No. 2, in which some translation of an article (mostly of a part of an article) is required. The assignments become more and more complicated until the student is able to prepare a written characterization of the given periodical (in English). He is then required to find the American counterpart of that periodical and to compare them.

Obviously, reading and translation of technical articles arouse interest and provoke discussion along the lines already mentioned. It is desirable therefore, that in a school of engineering instructors in foreign languages be engineers.

The work may take from two months to one year, depending on the degree of preparedness of the student. Lately the writer had a student who already possessed good knowledge of both German and French when he came. He worked hard, however, during two summer months and passed through twelve solid assignments. As an example his examination questions in German are given below:

Examination Questions in German

Do not use dictionary or any other book of yours

1. Translate the section entitled "Belastungsannahmen" of the article "Umbau der St. Ericksbrücke in Stockholm," *Beton und Eisen*, vol. 14, July 20, 1938, page 234.
2. Open the booklet "Führer durch die technische Mechanik" on page 20. Give the English equivalents of all titles printed in heavy types.
3. Write in English a brief outline (about 15 lines) of the book review "Versuche über die Eigenschaft des Hölzer nach der Trocknung," *Beton und Eisen*, vol. 14, July 20, 1938, page 11, Textbeilage.
4. Write a comparative characterization of the German periodical "Die Bautechnik" and of the French periodical "Travaux."
5. Who was Müller-Breslau? Culmann?

6. You are given two copies of the journal *Wasserkraft und Wasserwirtschaft*. This is a new journal to you.
   Find out:
   (*a*) The name of the editor;
   (*b*) Where the journal is published;
   (*c*) Define the lines of interest and write a brief characterization of this journal;
   (*d*) Is this journal interesting for an American structural engineer? Why?

As a rule, during the course (if this informal instruction may be termed so), the student becomes acquainted with the following periodicals:

(*a*) *German:*
Zeitschrift für angewandte Mathematik und Mechanik
Zeitschrift für Mechanik
Die Bautechnik
Der Bauingenieur
Beton und Eisen
Verkehrstechnik
Zeitschrift des Vereins der deutschen Ingenieure (V.D.I.)

(*b*) *French:*
Annales des ponts et chaussées
Le Génie Civil
Travaux

The student completes his work by becoming familiar with the proceedings of the international congresses (Road Congresses; Congresses of Large Dams; Congresses of Applied Mechanics; Congresses of Structural Engineering). Both foreign and English versions of the corresponding proceedings are used.

Work During the War and in the Post-War Period

The term "engineer" will be used hereafter to designate the American engineer of any speciality. We are at war now with Germany and are perhaps on the eve of the second front in Germany itself. In this occasion our present juniors and seniors who possibly will be army or navy officers at that time will have necessarily to do with German engineers and German populations. The lessons of history should not be forgotten. One of the first things the Germans had to do after occupying Holland was to put Dutch civil engineers to work for them notwithstanding the superabundance of their own technical forces. If a similar situation occurs sometime to the American army in Germany, a little of the German language and some understanding of the German mind will not

harm. Of course, a vast program of study as described above is out of the question at the present time.

It is risky business to prophesy what may happen after the war, but as the writer sees the situation, American engineers with knowledge of foreign languages will be needed in great numbers for restoration work both in Europe and in Asia. As foreign industry is restored, it will necessarily compete again with the American, and products "made in Japan" and "made in Germany" will reappear on the market. To be successful in the economic struggle one must understand well both his friends and his enemies, and this is impossible without knowing how they talk and what they think. Again, it is quite possible that after the war, the study of other languages, for instance of Russian or of Spanish, may become necessary.

It may be argued that as the time passes the English language occupies more and more field and may become international like Latin in ancient times. This is perfectly true; but it is also to be remembered that the Romans studied foreign languages, and borrowed some worthwhile technical ideas from abroad. For example, Vitruvius' books on Architecture contain a goodly number of Greek examples.

RELATING WRITING TO THE ENGINEERING CURRICULUM

By C. A. Brown,

Chairman, English and Coördination Department, General Motors Institute

AND

J. P. Riebel,

Instructor in English

In the chapter entitled "Conclusions and Recommendations" which Dean H. P. Hammond wrote as a part of the report on *Instruction in English in Engineering Colleges*, he says, "For good results in English, it cannot be said too often that the active support and coöperation of the engineering staff are indispensable." With this we all agree, but, it being a truism that coöperation works both ways, unless we go out of our way to render service to the engineering faculty, we can hardly expect the reciprocal treatment. This note describes an effort on the part of some teachers of English to engineering students to render such service.

At the General Motors Institute, we went to all of the departments of instruction and asked for topics that had been covered in the first two months and upon which students could be expected to write papers from one paragraph to two or three pages in length. Members of the various departments were very enthusiastic. The Science Department, for example, said that their freshmen at the end of two months could be expected to write on such topics as Plastic and Elastic Deformation, the Steel Code, Tensile Strength, Malleability, Alloys, the Tensile Test Piece, or the Metric System. The Mathematics Department offers as possibilities assignments such as Computing the Quotient by Logarithms, Finding the Side of a Right Triangle from a Known Side and a Known Angle, Computing a Product by Logarithms, or Interpolation for Seconds—Natural Function.

In Foundry Practice students should be able to write on such topics as the Fundamentals of Iron Ore Production, the Blast Furnace, the Construction and Operation of the Cupola, Different Types of Patterns, Types of Molding Machines, Production Foundry Technique vs. Jobbing Foundry Technique, or the Use and Manufacture of Cores.

Mechanical Drawing students might be expected to write on such topics as the Use of Drawing Instruments, the Arrangement of Views, Orthographic Projections, or Fillets and Rounds.

Machine Shop topics abound. A few are Speeds and Feeds in Cutting Steel, Uses of Height Gages, the Uses of Surface Gages, Types of Files, Safety Precautions in Bench Work, the Development of a True Flat Surface, and Layout Tools.

The English Department is not omitted from our list. Since we cover the writing of technical reports during the first month, we can and do expect our students to write about the physical make-up of a technical report. Other topics include Agreement, Reference, and Making a Tentative Outline.

The advantages are, of course, obvious. Here is a fund of class theme topics for the teacher who has difficulty in finding subjects upon which students can easily write. Some of the topics lend themselves readily to practice in paragraph development.

Still other uses may be made of such a list. For example, following a discussion of classification and organization, we asked our students to prepare an outline for a paper on "Types of Files." The accurate use of words can be emphasized, since the slovenly use of words is unthinkable in the field of work in which a young man expects to make his career. When an embryo engineer wrote, "A meter is a yard that is 39.37 inches long," we were able to help him.

One more word may be said concerning the use of technical subject matter in the English courses. At the meeting of the Teachers of English in Technical Schools held in Ann Arbor in 1941, we devoted one session to technical writing. At that meeting the suggestion was made that the English teachers need not hesitate in having students write on technical subjects simply because they were afraid they might not comprehend the subject matter. Mr. Thomas O. Richards, Head of Laboratory Control Department of the Research Laboratories Division of General Motors, agreed, and, in fact, went on to say that except for "fruit canning" (highly technical information for the internal use of an organization) any paper on a scientific topic should be understandable to any person as well educated as the average English teacher. If we welcome more papers on subjects of interest to our engineering students, we will perhaps be rendering a real service.

The more one thinks about the idea, the more possibilities appear. All that is required is a spirit of coöperation and a trip around the campus with pencil and note book. Succeeding trips will serve to keep the list up to date, and incidentally help the

rest of the faculty to get better acquainted with the members of the English Department.

Topics Suitable for Student Writing in English

Second School Month

Mechanical Drawing:
- The Various Drawing Instruments
- The Use of Drawing Instruments
- The Arrangement of Views: Orthographic Projections
- Fillets and Rounds

Machine Shop:
- What Is a Toolmaker?
- The Toolmaker's Trade
- Standard Machine Tools
- The Qualifications of a Good Mechanic
- Speeds and Feeds in Cutting Steel
- The Uses of Hand Scraping
- The Uses of Height Gages
- The Uses of Surface Gages
- The Types of Files
- The Purpose of a Layout
- Layout Tools
- Chisels Used in Shop Work
- Safety Precautions in Bench Work
- Various Heat Treat Operations
- The Purpose of Quenching
- The Purpose of Annealing
- The Development of a Flat True Surface

Mathematics:
- Logarithms
- Finding the Side of a Right Triangle from a Known Side and a Known Angle
- Finding an Acute Angle of a Right Triangle When Two Sides Are Given
- Computing a Quotient by Logarithms
- Computing a Root by Logarithms
- Computing a Product by Logarithms
- Interpolation for Seconds: Natural Functions
- Interpolation for Seconds: Logarithmic Functions

Science:
- Plastic Deformation
- Elastic Deformation

Alloys
The Steel Code
Density vs. Specific Gravity
Tensile Strength
Hardness
Toughness
Malleability
Ductility
The Tensile Test Piece
The Metric System

Foundry Practice:
Explain the Fundamentals of Sand Casting
(*a*) Materials used
(*b*) Making the Sand Mold
(*c*) Pouring the Castings
(*d*) Cleaning the Casting
The Fundamentals of Iron Ore Reduction
The Blast Furnace
The Construction and Operation of a Cupola
Production Foundry Technique vs. Jobbing Foundry Technique
The Parts of the Mold
Different Types of Patterns
The Use and Manufacture of Cores
Hand Tools Used by a Molder
Two Types of Molding Machines
How to Make a Pattern

English:
The Coördination Report
Agreement
Reference
The Importance of a Technical Education in Wartime
Selecting a Subject
The Tentative Outline

ENGINEERING JOB AND TRAINING OPPORTUNITIES IN THE AIRCRAFT INDUSTRY*

By C. T. REID

Douglas Aircraft Company, Inc.

I. DEPARTMENTS AND CLASSIFICATIONS OF WORK

Since the present engineering training in the aircraft industry embraces practically all phases of the engineering work, it is desirable first to make sure of just what the subdivisions of engineering work are before reviewing the courses. The engineering done to produce an airplane is not any one man's duty, nor is it a fixed or simple process. Rather it is the combined effort of a team of specialists who "exchange signals" and "make plays" as required by the particular situation, always in joint effort. Best known among these specialists may be the very few whose duties include the largest share of aeronautical glamour, such as the aerodynamicist and stress analyst. Because these are often best known, it is a common error to believe that aerodynamics and stress analysis make up the bulk of aeronautical engineering work. The less known men who constitute the great majority in our Engineering departments are the specialists in a dozen separate types of design. These types are largely branches of mechanical engineering. Often the work is so nearly purely mechanical engineering that the product of the factory might well be any other piece of intricate machinery than an airplane. These engineers populate the large groups that lay out the working parts of the airplane, develop arcs of movement, clearances, types of linkage and connections and determine strength to withstand design loads and vibration. They build mock-ups, make calculations and produce the working drawings. They are designers of control mechanisms, hydraulic systems, power plant installations, air conditioning equipment, electrical installations, interior furnishings, as well as of the skeleton work of the airplane itself.

From among the ranks of these design engineers come perhaps 99% of men promoted to such major engineering responsibilities as group leader, project engineer and chief engineer.

Aiding the main production groups are various auxiliaries. Prominent among them is the shop liaison group. Its duties are to

* Presented at the Texas Personnel Conference, University of Texas, October 29, 1942.

follow up design in the production departments of the plant. In close collaboration with the inspection department, the liaison engineers do trouble shooting, coördinating with production planning and with tooling, and operate an engineering salvage service.

Another important auxiliary group produces production breakdown illustrations. These illustrations are drawings made by people jointly trained in engineering drawing, art drawing and production methods. They enable us to place into the hands of our many new green shop workers blueprints that are pictorial, with 3 dimensional views, readily read and understood without the usual study of orthographic projection.

All these types of work require training. They also require good organization and direction, therefore, leadership training, in addition to the studies of individual engineering specialty functions, must receive proper attention.

II. Approaches to the Various Training Problems

Before the war we generally hired only the men who seemed to measure up to our stiffest specifications. We put them right to work and let them learn the methods and practices of our industry, and our particular companies and plants, by association with older employees. Demands for more and more engineers have come and the supply of available ones to hire has steadily dwindled. Simultaneously, the increase in pressure for war production has made it harder and harder to tolerate the production setback of assimilating new men right on the job. To meet this situation we have organized various break-in procedures. The usual plan is for a new comer to spend from 4 to 6 weeks full time every day in lectures, plant tours and practice on the drafting board under careful supervision. The program begins with a recheck of proficiency at mathematics and engineering drawing, with the mathematics treated primarily as to its application to layout drafting practices. Our designers must be acquainted with practical Descriptive Geometry as well as practical algebra and practical trigonometry. These three branches of mathematics find far more use in aircraft design work than does calculus or any still higher level of math. The study of engineering drawing must be fully applied to shop practices in metal product manufacture. An appreciation of the practices of the foundry, forge, machine shop and sheet metal shop is indispensable. Pattern draft angles, fillet radii, limits and tolerances on dimensions for various classes of fits, and standard forms of screw thread, must be understood.

While rechecking on these things (which should already be a part of the new man's knowledge before he comes to us), we give

the man a break-in to the aircraft industry, acquainting him with its nomenclature, materials, manufacturing customs and practice, standards of design, and government design regulations. Also, we take this occasion to acquaint him with the geography of the local plant and its rules of conduct. Finally, we help him to choose one of the design specialties and give him private coaching for a couple of weeks along that line. When he finishes the break-in course he is ready for a bonafide assignment of work vital to the war effort. By then we have made a considerable investment in his training, asking no return from his services meanwhile and even paying him at overtime rate for the extra hours involved in the heavy course.

This procedure is quite regularly followed both with new young men right out of college and older ones whose experience in other industries requires adaptation to our practices. Many women nowadays are included in this routine.

Next let us consider the very special attention given to an occasional outstanding young man. It has long been our practice to pick out a few young men each year for a very special training privilege. Their program consists of work time on a rotating schedule through all the main departments of the plant and all the administrative offices. We call it the shop experience course. It aims to enable students to gain first-hand contact with as many typical situations in production and management in a few months as ordinary experience would provide in several years. These young men are being groomed for key engineering and executive positions. Their alumni list runs high in percentage of responsible heads of various phases of our work.

To enter the shop experience course a man must be invited. Those who receive our management's invitation have shown by their conduct and associations during the early weeks of their employment that they stand head and shoulders above the crowd in proficiency and leadership qualities.

Besides these full time training activities, operating right on payroll time, there are part time programs which interrupt work for brief classes, lectures and study conferences, to develop better understanding of design specialities, new design practices, new material, and principles of supervision.

Outside of hours training activities are widely used. The typical university extension course, now so readily made available at no tuition cost through the E.S.M.W.T., is the best example. Large numbers of our engineers carry instructor assignments for a few hours per week covering the various design specialities and principles of engineering management. These classes operate at night for day workers, and in the daytime for night workers as well.

They are located anywhere convenient to the student, sometimes right in our own factory buildings.

All the classes we operate or support have been born of necessity. Usually they have been set-up to meet an actual emergency need. We find ourselves in the school business although rather unwillingly. We would prefer to lean upon those institutions who make education their profession, and accordingly know best how to carry it through. However, we are not unwilling to assume whatever may prove to be our fair share of the load. We expect to have always a certain amount of job training and local familiarization to handle.

Last but not least to mention among our engineering training efforts is the promotional work with the schools and colleges. There was a hint of this in our earlier remarks about desirable pre-requisites for the break-in. To any educational institution that shows good prospect of being able to make good use of it, we are eager to furnish in detail the particulars of what training it takes to qualify an engineering employee to serve our needs. We find this curriculum building a slow, tedious process. It required much patience. Often it is very discouraging. It always seems far easier to persuade whatever company is present, of a need than to get something positive done about it. I'm glad to say that deep in the heart of Texas we regularly find much better coöperation than the national average.

We urge that the college training of engineers be given more of a practical flavor. We would like to see more emphasis upon production values. In mathematics, physics and metallurgy there is an opportunity to teach through problems making direct application to production situations. If this is done there will be a distinct improvement in the qualifications of the applicants who come to us for jobs.

We want to see more training of women for technical work. We turn strongly to them for help in these days of absence of sufficient, available men. We find now that technically trained women are very scarce. It may be well to offer them a course of no more than one year duration to cover the high points of usual pre-engineering studies in mathematics, mechanics and drawing plus a few aeronautics specialities like materials and manufacturing processes. We do not recommend including aerodynamics or stress analysis in such a course. The year referred to should be a full calender year of 12 months, not just a school year, and might even include 6 day week operation.

III. Forecast

In closing perhaps a word of forecast is in order. What are the industry's engineering man-power needs for the war? Well, a recent survey of the plans of the 8 companies operating in California shows a larger number of engineering college graduates desired before the end of 1943 than will likely graduate from the entire nation's colleges without Army or Navy commissions. And we are just talking about California companies.

Many young engineers we interview want to know about employment conditions after the war. Sympathizing fully with this yearning for knowledge we gaze into our crystal ball and through the fog seem to see a few things fairly plainly. One is, all the experience now being gained in straight line point-to-point air cargo operation over land or sea indiscriminately with the world's largest land planes isn't going to be just tossed aside on an armistice day. Another thing we can see is, the steady stream of travelers on official war business who commute by air between the capitols of the continents, who are too spoiled for any slower transportation to think of giving up the present style.

We don't have to wait for perfection of a poor man's airplane to find a non-military market for aircraft. There is an enormous market now, potential and real, for common carriers. Surely the engineers engaged in the manufacture of these have better than average chances of permanency and steady rise.

Right now the opportunities are infinite. The aircraft industry is glad to hire at its door steps any man or woman of personal eligibility who has mastered just the bare fundamentals of our technical jobs. In fact many are being put on the payroll with the most obscure qualifications, and patiently lead by the hand through a familiarization period. Engineering training in the aircraft industry at the present time is one of that industry's most serious engineering problems.

PROFESSIONAL ENGINEERING DEGREES

By G. M. BUTLER

Dean, College of Engineering, University of Arizona

In the spring of 1942 a committee that consisted of Dean T. G. Chapman and the writer, created in the University of Arizona, was assigned the task of investigating practices followed in granting professional degrees, and formulating a procedure to be followed in Arizona.

Questionnaires were prepared and mailed to the deans or presidents of all engineering colleges in which one or more curricula had been accredited by E.C.P.D., including mining colleges, and 85 of these questionnaires were filled in and returned. From them the data herein given were compiled.

Sixty-two institutions, or 78 per cent, certainly confer these degrees, while 22 institutions do not do so, and the tenor of one reply was doubtful.

Three institutions, Colorado School of Mines, Columbia University, and Michigan School of Mines, confer them as baccalaureate degrees, and three colleges grant them as graduate degrees after a fifth year in residence.

By 44 institutions they are considered earned degrees; by 6, honorary degrees; by 7, both earned and honorary; and 6 did not give this information.

Fifteen colleges require a thesis (which involves research in 10 of them), 13 require a report that covers engineering work of which the candidate was in responsible charge, 28 accept either such a thesis or report, 4 require neither a thesis nor a report, and 3 did not furnish this information.

Fifty-four institutions require that the thesis or report be deposited in the general library; one requires that a thesis, but not a report, be deposited in that library; one that a thesis or report be deposited in the departmental library; and 3 did not furnish this information.

One college requires that a second copy of the thesis or report be deposited in the college library, and another college demands that it be placed also in the departmental library.

The time that must elapse after a baccalaureate degree has been received before a graduate is eligible for a professional degree varies from one to ten years; the weighted average is 4.45 years.

About a third of the institutions that do not grant these degrees until three or more years after graduation require that for from three to five years a candidate shall have been in responsible charge of engineering work.

Forty-seven institutions grant these degrees only to their own graduates, eleven sometimes confer them on graduates of other institutions, and four failed to give this information.

Forty-six institutions confer these degrees only upon graduates who have made an outstanding professional record; six colleges confer them as a routine matter without consideration of the nature of the candidates' experience as engineers; and eleven institutions withheld this information.

As compared with the number of undergraduate degrees conferred, 71 per cent of the colleges that supplied this information eventually confer two per cent, or less, as many professional degrees. The relatively small number of such degrees conferred emphasizes the fact already stated that, in most instances, the conferment of these degrees is decidedly not a routine matter.

One college reports that it grants these degrees to graduates who have had at least five years of practical experience provided they have done above average undergraduate work, while another institution grants these degrees only to registered professional engineers.

Consideration of the facts given shows that an institution will conform to the practice that prevails in the majority of the engineering colleges in the country if it observes the following regulations:

Professional engineering degrees which are regarded as earned, not honorary, are granted to the colleges' own graduates, only, who have made outstandingly good professional records during not less than about five years after baccalaureate degrees are conferred, provided the candidates themselves apply for the degrees, and provided, also, that such applications are supported by either a thesis that may or may not involve research or a report on professional work done by the candidate, which thesis or report is deposited in the institution's general library.

THE "ENERGY METHOD," WHICH ONE? *

By ALFRED S. NILES

Professor of Aeronautic Engineering, Stanford University

SUMMARY

After a general discussion of possible systems for designating calculation procedures applicable to structural analysis, some specific suggestions are made regarding the group of procedures that often pass under the name of "the energy method." Many of the problems to be solved by the structural engineer fall into three distinct groups.

I. Determination of deformations and deflections of a structure subjected to known loads.
II. Computation of internal forces and external reactions for a statically indeterminate structure in equilibrium.
III. Determination for a structure in equilibrium whether that equilibrium is stable, neutral, or unstable. This includes problems of determining the "critical loading" at which equilibrium changes from stable to unstable.

Many of the procedures taught for solving problems in each of these groups involve conscious use of certain principles pertaining to the strain energy stored in the structure, and the work done by the external forces as they are being applied. Therefore many of these procedures are called "the energy method" or "the strain-energy method" by their proponents. If only one procedure were so designated there would be no confusion. At present, however, these terms are applied to so many radically different procedures that they are worthless for purposes of identification.

An important source of this confusion in terminology is failure to recognize effectively that very different practical procedures may be based on a single principle or group of principles, and also that a single procedure may be justified by resort to alternative groups of principles. For example, the analysis of a simple truss by the analytical method of joints, and the analysis of the same truss by drawing a reciprocal diagram, represent the application of exactly the same mechanical principles, but the procedures are entirely different. On the other hand, when the deflection of a

* Presented at the 50th annual meeting, S. P. E. E. (Aeronautical), New York City, June 27–29, 1942.

beam is computed by substituting numerical values in a handbook formula, there is nothing to indicate whether reliance is being placed on successive integration, elastic loads, an "energy method," or merely the veracity of an author and the alertness of a proof-reader. Similarly the use of the equation

$$\delta_a = \Sigma \frac{p_a P_0 L}{AE} + X_a \Sigma \frac{p_a^2 L}{AE} + X_b \Sigma \frac{p_a p_b L}{AE} + X_c \Sigma \frac{p_a p_c L}{AE} + \cdots$$

in the solution of a redundant truss may be considered, either as a specialized application of the Maxwell-Mohr method of deflection synthesis, or as a specialized application of the method of least work. In fact this very formula which is presented as an application of the former method in the second edition of "Airplane Structures," [2] was presented in the first edition [1] as an application of the latter.

While easy to point out defects in the present nomenclature of methods of analysis, it is not so easy to suggest satisfactory reforms. Three general systems are available for identifying a specific computation procedure: One, use the name of its originator; two, employ a word or phrase descriptive of some distinguishing feature of the method; three, refer to some principle on which it is based.

The weaknesses of the first system are, first that the originator of the method may be unknown so that credit may be given to the wrong man, and second that most of our methods, as used at present, have been developed by a sequence of workers among whom it is difficult to apportion credit. Some engineers also have originated more than one method of analysis, even for a single type of problem, and this situation would present difficulties.

The chief defect of any attempt to name procedures by distinguishing characteristics is that very few procedures have such characteristics.

The third method presents a number of problems. In the first place, it is rare that a procedure rests on a single principle. Normally it depends in varying degree on each of a group of principles, and opinions may vary regarding the relative importance of each. This makes it difficult to decide which principle to use in naming the method. At the same time there are the difficulties mentioned above, that a given procedure may be justified by resort to different principles, while a given principle may be the chief resort for proving the validity of several distinct procedures. In some cases, also, a procedure is originally based primarily on

[1] Niles, A. S., and Newell, J. S., "Airplane Structures," p. 328, 335; John Wiley and Sons, New York, 1929.

[2] Niles, A. S., and Newell, J. S., "Airplane Structures, 2d Ed. Vol. II, p. 12; John Wiley and Sons, New York, 1938.

one principle but later workers find it more easily justified by resort to a different principle, and the later derivation is the one commonly used in the textbooks. The student is then confused by the fact that the procedure is designated by the name of a principle to which it bears no apparent relationship.

This last difficulty is largely due to the fact that most of the "principles" underlying methods of structural analysis are not independent fundamental theorems. As Mach points out repeatedly in "The Science of Mechanics" the actual subconscious basis for recognising the truth of a theorem in mechanics is seldom, if ever, used as the starting point of a formal proof of its validity. One starts from whatever phase of general truth appeals to him as self-evident, or at least as firmly established, and then proceeds by more or less rigorous mathematical processes to prove the truth of the phase which he considers less obvious or less well established. For example, Mach shows that when critically considered all of the "proofs" of the principle of virtual work may be reduced to the statement that "when nothing can happen nothing will happen."[3] Thus the so-called "principles" are often not expressions of different facts, but statements of different aspects of the same fact, or statements of a familiar fact in a new form.

This should not be interpreted to mean that the various "principles of mechanics" found in the text-books are of no value to the engineer. They are of great value in leading to economy of thought, and may be likened to the bench marks showing elevations above sea level, which are set up by the U. S. Geological Survey to make it unnecessary to start each new line of levels at the sea coast with a redetermination of mean tide. They act similarly as reliable mental datum points from which to start a new train of reasoning without having to repeat and duplicate earlier work. The individual writer in proving the validity of a procedure has a free choice of the "mental bench mark" from which he will start his line of reasoning, and it is only to be expected that different writers will make different choices.

Another defect of the practice of using the names of mechanical principles for identification purposes comes from lack of consistency in the formal definitions of those principles. Thus Weld in his "Glossary of Physics" defines the principle of Virtual Work as that which "states that a condition for the equilibrium of a system is that the total virtual work due to all internal and external forces acting upon the system is zero; or in other words, that the potential energy of the system is a minimum or a maximum or constant."[4]

[3] Mach, E., "The Science of Mechanics," p. 76; The Open Court Publishing Co., Chicago, 1893.

[4] Weld, L. D., "Glossary of Physics," p. 247; McGraw-Hill Book Co., New York, 1937.

Fife and Wilbur in the "Theory of Statically Indeterminate Structures" define it thus, "If a body is in equilibrium and remains in equilibrium while it is subjected to a small virtual distortion, the virtual work done by the external forces acting on the body, plus the virtual work done by the inertia forces, is equal to the virtual work of distortion."[5]

Here are two definitions, one in which the total virtual work must be zero, and another in which one class of virtual work must be numerically equal to another class. These definitions are not verbally identical, and they actually do not describe the same aspect, but two closely related aspects, of the fundamental fact mentioned by Mach. Either may be used as the starting point of a train of reasoning to justify any procedure that could be properly called a "method of virtual work." If Weld's definition is used the first step would normally be a resort to the principle of conservation of energy to prove the truth of Fife and Wilbur's. From that point on the trains of reasoning would be identical. In this case, therefore, the use of the same name for two different but closely related aspects of the same body of fact does not result in any differences in the derived computation procedures. On the other hand, the engineer who starts from Weld's definition recognizes his procedure is based upon the principle of conservation of energy as well as that of virtual work, while the engineer who starts from Fife and Wilbur's definition may fail to recognize that fact. Until there is closer agreement among writers regarding the exact aspect of the body of fundamental fact described by a given named principle, considerable care must be taken when stating that a certain computation procedure is based on that principle. Otherwise the user of the procedure is likely to lack a proper grasp of the reasoning on which it is based, and therefore of its exact scope and limitations.

Perhaps the best solution of the problem of nomenclature is to attempt a judicious use of all three systems simultaneously. If a procedure has a feature which does differentiate it from its alternatives, that feature is the best basis for a name for the method. If it can be established that a procedure was originally developed by a specific individual, or brought to essentially its present form by a specific individual, the method is best known by his name. Often it will be proper to use the name of a man who was neither originator nor perfecter of the method, but the one who had so great a share in its development and application to general practice that his name is naturally associated with it. The employment of the basic principle used for the name of a method is normally un-

[5] Fife, W. M., and Wilbur, J. B., "Theory of Statically Indeterminate Structures," p. 18; McGraw-Hill Book Co., New York, 1937.

desirable, and should be resorted to only when the method is an obvious use of that principle according to any of its more common formulations, and it can be derived from alternative principles only by the use of awkward and round-about lines of reasoning. In a great many cases *no* satisfactory designation can be obtained by the use of a single basis of nomenclature. Then it is best to use both the most appropriate personal name, and either a distinguishing feature of the procedure or a principle on which it is based.

Another source of trouble in developing a system of nomenclature for methods of analysis is that it is seldom that two writers describe a given method identically. Each has his individual manner of deriving it, and usually there are also differences in the suggested manner of application. If each variation were given an individual name, their designations would be so numerous that they would no longer be effective for purposes of identification. Most of the methods, however, fall into groups and it is usually sufficient if the group to which a given procedure belongs is clearly identified. One might say they are variations on a certain theme, and be content with identifying the theme without trying to specify in detail the variation. Even so there would be difficulty with a method, and there are many of them, which is a combination of procedures of two or more usually distinct groups. In such cases perhaps the best solution is to use the name of the originator, at least until enough minor variations of his method have appeared to justify the recognition of a new group.

The above remarks are general in character and it is desirable to show how the principles of nomenclature advocated might be applied in practice. This will be done in connection with the more important "energy" methods. No detailed descriptions of these methods will be attempted here as they are all adequately described in the references.

Deflection Computations

The most commonly used "energy method" for computing deflections is that which was independently developed by Maxwell in England and Mohr in Germany. This method is described in several textbooks [6] in which the proof of its validity closely paral-

[6] Niles, A. S., and Newell, J. S., *op. cit.*, 2d Ed., Vol. I, pp. 373–392; Parcel, J. I., and Maney, G. A., "Statically Indeterminate Stresses," 2d Ed., pp. 13–36; John Wiley and Sons, New York, 1936; Spofford, C. M., "Theory of Structures," 3d Ed., pp. 359–370; McGraw-Hill Book Co., New York, 1928. These and the following references to descriptions of the various computation procedures are not intended to be exhaustive but only representative. Additional references could have been included but the writer could see no gain in so doing.

lels that of Maxwell, but covers a wider range of problems. This proof is based primarily on the proposition that when a structure subjected to loads is so deformed that all the energy represented by the work done by the forces acting on the surface of the structure is transformed into strain energy of its elements, the work done by the forces acting on these elements during the deformation is an independent alternative measure of that energy. This proposition is essentially a direct application of the more general principle of conservation of energy to the type of event under consideration, and can be derived without resort to the principle of virtual work. Mohr, on the other hand, develops practically the same procedure as an application of the principle of virtual work. Maxwell's work was not made familiar to engineers until after Mohr had introduced the procedure to common practice, and most engineers have followed Mohr's example of terming it the Method of Virtual Work. Sometimes it is termed the Method of Virtual Velocities or Virtual Displacements, those being alternative names of the principle in question. Although the writer calls the method that of Virtual Work in his book he is not at all satisfied with this terminology since, following the example of Clerk Maxwell[7] and C. M. Spofford,[6] he did not use that principle in its development, with the result that the reader of his book can see no connection between the procedure and its name. He now believes that it would have been better to have followed those authors who call it the Dummy Unit Load Method, since the use of a dummy unit load is its striking characteristic.

A second "energy method" of computing deflections is also described in several texts.[8] The chief characteristic of this procedure is a differentiation of the expression for the strain energy stored in the structure as a result of imposing the loads causing the deflections desired. This procedure may be justified as a modification of the Dummy Unit Load Method, or as a direct application of a principle promulgated by Castigliano. Writers differ as to whether the principle in question should be called Castigliano's first or second theorem. Pippard and Baker term it the former and Fife and Wilbur the latter. For purposes of identification it is suggested that the procedure be termed the "Use of Castigliano's theorem," dodging the question of the number of that theorem. This practice should not result in confusion with the method of Least Work developed by Castigliano, since the latter is used to compute stresses and *not* deflections.

[7] Maxwell, J. C., "On the Calculation of the Equilibrium and Stiffness of Frames," *Philosophical Magazine*, London, April, 1864.

[8] Niles, A. S., and Newell, J. S., *op. cit.*, 2d Ed., Vol. I, pp. 394–396; Parcel, J. I., and Maney, G. A., *op. cit.*, pp. 36–40; Timoshenko, S., "Strength of Materials," Vol. I, pp. 318–326, D. Van Nostrand Co., New York, 1930.

Still a third "energy method" is described by Timoshenko in his "Theory of Elastic Stability."[9] In this procedure the principle of virtual work is used explicitly as an essential element in determining the coefficients of a Fourier series representing the elastic curve, and the desired deflection is obtained by evaluating the first few terms of the series. This method could well be called Timoshenko's Method of Virtual Displacements. Although Dr. Timoshenko has informed the writer that the possibility of applying this method was suggested by the work of Lord Rayleigh, it was Dr. Timoshenko who developed it into a practical tool for engineering use. It therefore properly can carry his name. The use of his name distinguishes this method from the older one due to Maxwell and Mohr, and the use of the term Virtual Displacements in place of Virtual Work might prove helpful in achieving the same end. This substitution is particularly fitting since Dr. Timoshenko normally speaks of virtual displacements rather than virtual work. It may be noted it would be exceedingly difficult to justify this method without some resort to the principle of virtual work, while it is the opinion of the writer that the procedure of Mohr can be more readily justified and understood if there is no mention of that principle. Dr. Timoshenko suggests that this method should be called the Trigonometric Series Method.

Methods of Analyzing Redundant Structures.

Several methods are in use for obtaining deformation equations needed to supplement the equilibrium equations in analyzing redundant structures. Some, following the lead of Maxwell and Mohr, apply the method of superposition to obtain equations expressing certain known deflections of the structure in terms of deflections due to the known values of the external loads and the unknown redundant forces. This method is described in many texts[10] and is often termed the Maxwell-Mohr Method. It is difficult to devise an entirely satisfactory name for this procedure, and the best the writer can suggest is the "Maxwell-Mohr method of synthetic deflections." This phrase not only gives the name of the chief originators of the method, but also suggests the procedure of building up the deformation equations by combining or synthesizing deflections due to the various forces involved. The expression "synthesized deflections" might be logically preferable, but it is too much of a tongue twister. When the necessary deflec-

[9] Timoshenko, S., "The Theory of Elastic Stability," pp. 23–31, McGraw-Hill Book Co., New York, 1936.

[10] Niles, A. S., and Newell, J. S., *op. cit.*, Vol. II, pp. 5–15; Parcel, J. I., and Maney, G. A., *op. cit.*, pp. 90–115; Spofford, C. M., *op. cit.*, pp. 417–422; Sutherland, H., and Bowman, H. L., *op. cit.*, pp. 223–231.

tions are obtained by the Dummy Unit Load Method it is sometimes referred to as an "energy method", but that is a misnomer, since the essential element of the procedure is the system of developing deformation equations, and that is independent of the procedure employed to compute the deflections used. This is true even though the special formulas used for specific classes of problems are those resulting from the use of the Dummy Unit Load Method. Dr. Timoshenko has suggested the method be termed simply the Maxwell-Mohr Method without further qualification.

An alternative to the Maxwell-Mohr method for computing stresses is the Method of Least Work.[11] As shown by its derivation in "Airplane Structures", this can be considered as a system of using the Maxwell-Mohr method with the necessary deflections determined by Castigliano's Theorem, and the calculations so arranged that the individual deflections needed are not consciously computed. On the other hand it may properly be regarded as a direct application of the Principle of Least Work, and therefore rightly termed an Energy Method. On the whole it seems better to call this the Method of Least Work, thus specifying the particular principle most obviously employed, than to use the more general and thus more ambiguous term of Strain Energy Method.

Determination of Type of Stability

When it is desired to determine from energy considerations whether a condition of equilibrium is stable or unstable, or the critical load with respect to elastic instability, resort is usually had to a method first used by Perry and Bryan, but extended to a much wider range of problems and effectively introduced to engineering practice by Dr. Timoshenko. This method, which is fully developed in his "Theory of Elastic Stability" is based upon the principle, first enunciated by Maupertuis, that for a system to be in stable equilibrium, its potential energy must be a minimum with respect to any geometrically possible change in configuration. This "principle of 'least energy' " must be carefully distinguished from Castigliano's much more limited "principle of least work." It is carefully described in Art. 14 of the "Theory of Elastic Stability," and numerous applications are made of it in the remainder of that text. The application of the principle to an ideal column is also outlined in "Airplane Structures."[12] Although the method has been used in some isolated problems by other writers, Dr.

[11] Niles, A. S., and Newell, J. S., *op. cit.*, Vol. II, pp. 20–29; Parcel, J. I., and Maney, G. A., *op. cit.*, pp. 121–125; Spofford, C. M., *op. cit.*, pp. 422–437; Sutherland and Bowman, *op. cit.*, pp. 184–186, 217–223; Timoshenko, S., "Strength of Materials," Vol. I, pp. 327–336.

[12] Niles, A. S., and Newell, J. S., *op. cit.*, Vol. I, pp. 274–287.

Timoshenko has done so much to develop its use and make it a part of accepted practice that it is most appropriately called Timoshenko's Method, or Timoshenko's Method of Computing Critical Loads.

The writer does not expect instant and complete acceptance of his suggestions for naming the various "energy methods" of analysis. Others will prefer alternative designations for some of the methods, and many of their suggestions will have more merit than those in this paper. The writer would like to see the Society for the Promotion of Engineering Education create a committee on nomenclature to study the problem and promulgate a system of designating analysis procedures that might be generally accepted by the authors of textbooks. The work of such a committee should not be limited to the narrow field of energy methods for solving structural problems, but should have a much greater scope. In fact it would be desirable to have enough committees named that all branches of engineering could be covered. If such action is not practicable it is suggested that authors, when they first refer to a method of analysis, not only give it as suitable a name as possible, but also give a reference to the particular book or paper in which the exact procedure referred to is described.

One cannot reasonably hope to eliminate the present confusion in nomenclature by a single short paper. This one will have served its purpose, however, if it stimulates discussion, and helps to eliminate the all too prevalent practice of calling *any* computation in which considerations of energy are directly, or even indirectly, involved "THE Energy Method."

DEPARTMENTAL AND INTER-DEPARTMENTAL RESEARCH IN HEAT-POWER ENGINEERING*

By FRANK O. ELLENWOOD

John Edson Sweet Professor of Engineering, Cornell University

Now that our country is at war with ruthless enemies who have long cared little for the individual, it is appropriate that we, as individuals, should reappraise our own coöperative efforts in all branches of work, regardless of whether it is engineering research or not. This statement has special significance for us when we observe some individuals who lack the proper public spirit as exemplified by their willful attempts to continue to live just as though we were not engaged in the world's greatest war. When we try to determine the cause of these defects in some of our citizens in war time, we find the tendency is to blame the educational program of our secondary schools and colleges. In this connection it may be said, in general, that when the shortcomings of our citizens are held up before us, the educational program is blamed whether justly or not. On the other hand, most of our secondary schools and colleges have probably been somewhat at fault in emphasizing the importance of the individual and in failing to stress the privileges and duties of each member of a democratic society.

In our universities, one might naturally expect to find the closest coöperation between different departments in all branches of research that involve common points of interest. Upon investigation, unfortunately, one sometimes finds that major differences of opinion, jealousies, and personal dislikes may interfere with real inter-departmental research. The same human characteristics often show up, even to a greater degree, in many large commercial organizations. When these situations arise, they are embarrasing to all concerned, to say the least; and those in charge of the departments are often not aware of the lack of coöperation until some unusually bad delay in the work brings it to their attention. Any one engaged in research in heat-power engineering is likely to be brought into contact with many other departments, such as mechanical laboratory, shops, physics, chemistry, and mathematics. The author's experience with these departments has generally shown a sincere desire on their part for full and helpful coöperation.

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In this connection it seems appropriate to specify a typical example that brings out clearly the advantages of whole-hearted coöperation between different groups. Recently one of the members of our heat-power department desired to make an instrument for measuring the angle factors in radiation. He showed pencil sketches of the device to the Superintendent of shops and asked for suggestions. This Superintendent is exceptionally well trained technically, and is a man of keen insight regarding new designs; he is also always pleased to help those in other departments. It will not, therefore, surprise you to learn that in this instance several valuable suggestions were offered by the Superintendent to improve the design structurally and also to make it easier to construct. These suggestions were immediately recognized by the original designer as valuable ones; and the device was soon constructed and placed in successful use. This pleasant picture is just the opposite of that sometimes seen when two or more departments are involved in almost endless controversies over delays and certain details of a new project.

At the present time, heat-power engineers throughout this country are effectively struggling with a production program that is astounding, and that properly takes precedence over research. This statement applies to internal-combustion engines for airplanes, tanks, trucks, tractors, submarines, locomotives, and small ships; to steam-generating equipment, turbines, and engines for naval vessels and freighters; also to steam locomotives and to large steam-electric central stations. As an example of the magnitude of the problem, consider the central-station industry, concerning which the general public usually hears but little. It has recently been announced by the War Production Board that the electrical energy to be expended annually for our war effort alone will soon reach 140 billion kwhr. This tremendous amount of energy can be visualized, to some extent possibly, by noting that it lacks less than 4 per cent of equaling the total output of all our central stations for every purpose during the year 1940. Under these circumstances, naturally, the subject of research in this field becomes of secondary importance to that of immediate production. To help the central stations meet their abnormal demands the War Production Board has ordered all utilities to operate their systems in such a way that the maximum output may be obtained from their present capacity, and to establish interconnection with other systems to enable exchange of energy from all sources. This drastic order applies to small private power plants (of 100 kw or more) as well as to the large central stations. The companies that are furnishing electrical energy to a community through a vast network of interconnections between large and small power plants

face the difficulty of carrying the load, and at the same time establishing fair rates for the exchange of electrical energy between the plants concerned. This problem has often been a real stumbling block in the way of interconnections between large and small systems; and it is now before us in even a more complicated form as one of the realities of war. For its solution, we need the hearty coöperation of many concerns with the director of industry operations. Possibly numerous members of our society who are well trained in heat-power engineering and who have the proper cooperative spirit will be called upon to assist in this work.

Our large steam plants are constantly making progress in the successful use of steam of higher pressures and temperatures. This statement applies to our naval and marine installations as well as to those on land. In all of these plants, as the maximum demand for steam becomes more nearly continuous due to the war, the greater become the chances of outages due to imperfect feedwater. The troubles from this source are intensified if the boiler circulation is not ample; and many engineers now believe that the forced-circulation type of boiler is, at least, part of the solution of the problem. It seems logical, therefore, to expect that all of us will study carefully and with intense interest the performance of the forced-circulation unit recently installed at the Somerset Station of the Montaup Electric Company.

Careful consideration of the general problem of maintaining comfortable conditions in our homes and public buildings will show that we need further coöperative research between physiologists, architects, and engineers. From the standpoint of comfort, some of our heating systems are but one step removed from an open fire in the corner of an enclosure. The entire problem should be investigated from the viewpoint of providing comfort and, at the same time, conserving our national resources. Further information is needed regarding the heat-transfer characteristics of materials and types of construction that may eventually be found superior to those in common use today. This statement is particularly true when the effects of unsteady heat flow are considered.

For the internal-combustion engine, the war makes it essential to appropriate staggering sums of money for production and research. Our airplane engines must be constantly improved to keep ahead of those of the enemy. Most of this work will be done by the research departments of the army, navy, and the engine manufacturers, because the equipment involved is too elaborate and expensive for our universities. There are, however, certain fundamental truths yet to be discovered in many branches of this work, and the universities can help in such research projects. For example, the supercharger is a vital part of the engine used in mili-

tary air craft today, but in our present study of this device, we need to develop instruments and technique for the measurement of pressure, temperature, and velocity of fluids at supersonic velocities. Further research is needed on the fuel-induction system, bearings, lubrication, cooling systems, spark plugs, pistons, rings, valves, and cylinders. While our present record for continuous operation of airplane engines is extremely gratifying, no one will say that he is entirely satisfied, and that further improvements can not be confidently expected. For the compression-ignition engine, we need lighter engines that will still be reliable for long periods of continuous operation. The fuel-injection system, combustion chambers, cooling systems, lubrication systems, and various engine parts afford opportunity for further development.

Fuels that are suitable for various types of internal combustion engines are vital necessities of modern war. These fuels are also necessary for use in times of peace if we are to continue to live in our accustomed manner. Although we now lead the world in the quality and quantity of high grade petroleum fuels, it is gratifying to note that there has just been created by the joint action of the American Petroleum Institute and the Society of Automotive Engineers a new organization designated as *The Coöperative Research Council* whose purpose is "to centralize, correlate, and promote coöperative research activities of the automotive, aeronautic, and petroleum industries." This new organization should be able to do a vast amount of work that is valuable not only to their sponsors, but to all of us who are interested in this important field. The mere fact of its organization shows the proper spirit of its sponsors in trying to secure a greater degree of coöperation among this large group of research workers.

In the refrigeration field, the war has given the required impetus to develop some freon-12 centrifugal compressors that are really large—about 500 tons each. Although evaporators and condensers have been greatly improved during recent years, this work needs to be continued. For the vacuum system of refrigeration, the ejector is the heart that still baffles us when we try to analyze its losses. The refrigeration of foods, both in time of war and peace, affords a good opportunity for coöperative research by many individuals in widely separated fields. Here the engineer needs technical advice on what new foods are likely to be used, how they should be transported, and how they should be stored to retain their best nutritive values.

In many of our universities, our research programs have been already greatly curtailed as a result of the war; and it would require a superman to predict with confidence just what these programs may become after the war. It is certain, however, that research will

continue in industry and in our universities even though the funds available for the work may be appreciably less than in former years. The reduction in funds available for research, or even their elimination, need not be considered as a death blow to research in heat-power engineering or many other departments; because we trust that we shall still have our libraries, sliderules, paper, an pencils (but without rubbers possibly!). With this equipment and some really keen young minds eager to tackle difficult problems, a large amount of important work can be done without building any new apparatus or taking any additional readings. In other words, we have already available for us important observations that will require hard study to derive the general relations that we need. This part of the work is often far more difficult than the experimental portion. As one specific illustration of what is involved in the preceding statements, let me cite the effect of solar radiation and air-temperature differences upon the cooling load of air-conditioned buildings. This subject needs much additional analytical work done upon it before the enormous amount of data available in the publications of the American Society of Heating and Ventilating Engineers can be used most effectively.

As another example, most of you may recall that at the annual meeting of the American Society of Mechanical Engineers last December there was presented an excellent paper on "Studies of Heat Transmission Through Boiler Tubing at Pressures From 500 to 3300 psi" by six men from the Consolidated Edison Company. This paper contains numerous important features, among which may be found many pages of valuable data on heat transmission and also on the drop of pressure in high-pressure boiler tubes. Here is a case in which the magnitude and cost of the equipment involved were so great that the observed data could not be duplicated in any university laboratory now in existence or likely to be built in the future. The data are available, however, for many years of fruitful analytical research in our universities *by men who have sufficient ability, training, and determination to dig* further into nature's secrets in order that we may have available more general relations than are now known. Therefore, it seems appropriate to suggest that our university research programs should emphasize the importance of analytical work as well as laboratory observations.

In conclusion, the main points presented here may be summarized by saying that coöperative efforts of all individuals are essential in war time and advantageous at all times; that our educational program should always attempt to strengthen the coöperative spirit of our youth; that all research workers both in industry and in our universities should coöperate fully with others

whether in the same department or not; that, even though research funds are almost nil, much important analytical work can be done with observed data already available; that research work in the various fields of heat-power engineering is vital to our war efforts; and that most of these fields of activity, such as those pertaining to the internal combustion engine, the steam power plant, the air conditioning of our homes, the transportation of our freight, the efficient use of fuels, and the refrigeration of our foods are properly and generally considered essential to our normal American way of life.

BETTER TRAINING FOR COMMUNICATION ENGINEERING *

BY S. G. LUTZ

Naval Research Laboratory, Washington, D. C.

INTRODUCTION

Training for Electrical Communication Engineering has shown vast improvement during the past year. Prior to the war, many schools showed interest in improving their communication work but progress in this direction too often has been hampered by the belief that communication training is too specialized for undergraduate curricula. It is the viewpoint of this paper that much of our undergraduate electrical training actually has not been sufficiently general to meet the needs of men entering the communication field. It is believed that there has been so much power specialization in required courses that the needs of communication men often have been neglected.

This subject is so highly controversial that it must be understood that the opinions and conclusions to be expressed are purely personal and do not necessarily reflect the views of my employers, past or present.

SOURCES OF INFORMATION

As engineers, we are expected to discount personal opinions in favor of facts which have been established from experimental data. Consequently, let us commence by examining the types and sources of data used in the preparation of this paper. First, it seemed important to determine, with some accuracy, the relative percentages of our graduates who followed power work, communications, or who failed to follow electrical engineering. This information seemed essential to establish the relative importance of the communication field and the attention we are justified in devoting to it. Next, it seemed desirable to analyze the curricula of a representative number of schools to determine the relative emphasis now being placed upon the various phases of electrical training. Further data were assembled from an analysis of the more widely used "circuits" textbooks to determine the relative emphasis being placed upon power and communication applications. Finally, expressions of

* Presented at the 50th annual meeting, S. P. E. E. (E.E.), New York City, June 27–29, 1942.

opinion were obtained from a large number of teachers, engineers, and employers. It must be confessed that many of the author's personal opinions have been modified drastically by the information obtained from this survey.

Objectives of Communication Training

Before discussing the data which have been assembled it seems advisable to propose some definitions and objectives to clarify the aims of this paper. This paper is concerned solely with the technical aspects of communication training. The importance of the cultural and economic aspects of engineering education seems generally recognized.

The term "electrical communication" will be used in its broad sense to include all branches of the electrical art which are concerned primarily with conveying information of any kind. All such branches have one important common denominator; *they all involve the use of non-recurrent waves.* Since any non-recurrent change in a wave, as is necessary for communication, must set up a continuous band of frequencies, *finite bandwidth is a prime requirement of all communication circuits.*

This concept of bandwidth forms perhaps the most important distinction between the communication and power viewpoints of electrical engineering. The communication engineer usually considers frequency as his principal independent variable and studies circuit behavior over a broad band of frequencies. The power engineer generally assumes the frequency to be fixed and is more interested in the effects of varying the magnitude and power factor of this load. More obvious differences, such as the magnitudes of the quantities involved and the types of equipment used, seem of less fundamental importance.

In order to decide how the educational needs of a communication engineer may differ from those of a power engineer, let us first make some generalizations on the technical needs of all engineers. It is universally agreed that we cannot hope to teach a student every thing he may need to know. even in one specialized field of engineering. If a man is to achieve real technical success he must continue his education throughout his career; mastering new fields of knowledge and assimilating fresh information as the need for it arises and as it becomes available. Most of this new knowledge must be gained from the technical literature, rather than from texts. (It is no longer new by the time it gets in texts!) The engineer who attempts original work on a fresh problem without first searching the literature to find what information others have contributed to that problem inevitably wastes time and money

through duplication of effort. Any engineer faces a serious handicap if there is a large gap between the level of his training and the level of the technical literature he must read. Therefore, it seems that one of our greatest responsibilities is to give the student that knowledge which technical authors have the right to assume he is familiar with.

Of course the mere ability to digest technical literature is not sufficient in itself, for a good engineer must possess the technique, imagination, and judgment necessary to put this newly acquired information to work. The initial development of these qualities also is our responsibility. This reasoning may be summarized by saying that, "A well trained engineer is one who can read his technical literature intelligently and apply the information thus obtained."

It is believed that there has been a larger gap between the level of our undergraduate training and the level of the technical literature in the communication field than in the power field, and that this condition results largely from an inadequate balance in supposedly "general" courses.

Distribution of Employment

The requests for data on employment and curricula were mailed in the late summer of 1940, before the defense program had greatly stimulated the demand for communication men. Twenty-five schools with an average annual total of 666 graduates submitted information on relative employment for the five preceding years. Most replies probably were estimates but their average should be reasonably accurate. The averages were calculated from the number of graduates in each classification, rather than merely by averaging the percentages reported by both large and small schools. These averages showed 59.8 per cent employed in the power field, 25.0 per cent in the communication field, and 15.2 per cent in non-electrical fields or unemployed. In other words, about one out of four of our graduates entered communication work between 1935 and 1940, and there were only 2.4 power men for each communication man.

It is certain that a far larger percentage would apply today, when the majority of our graduates are being grabbed for communication work with the armed services, war industries, or the government. It also is certain that far less than 25 per cent found communication employment twenty or so years ago when the telephone industry was the principal employer of communication men. With post-war commercial exploitation of many now secret developments, it is reasonable to expect the communication industries to

continue absorbing an important percentage of our future graduates, and their educational needs will merit more careful consideration than they have received in the past.

Classification of Curricula

Initially, it seemed that it should be easy to compile an average curriculum purely from catalog information. While there are strong similarities between most curricula, it soon was evident that course titles and descriptions often were too ambiguous for accurate classification. For example, a course might be entitled "Electrical Problems" and described as "problems in electrical engineering." Only one having personal knowledge of the school could tell that this actually meant A.C. Machinery Laboratory!

To be fair to everyone, it appeared advisable to invite the individual schools to classify their curricula according to course content, rather than course titles. The classifications used are explained in appendix A, which is a copy of the instruction sheet accompanying the questionnaire submitted to the schools. The analyses have been based on only the work of the junior and senior years, plus elementary electrical courses given in the sophomore year.

Since this study was intended to show the distribution of courses available to a student who knew he wished to prepare for communication work, it was assumed that he would take all possible communication courses among his electives and take general theoretical courses, such as advanced physics or mathematics, for the balance of his electives unless this choice were specifically restricted in the catalog. This decision now appears to have been unfortunate because few students ever can schedule all such courses listed. Some such courses may be barred by conflicts, may be given on alternate years, or may be withdrawn if elected by less than a certain minimum numbers of students.

It probably would have been more useful to have based the analysis only on required courses; listing the time allotted to electives, and the available communication electives, as separate classifications. From a brief study of catalogs it appears that, while most schools offer communications, slightly less than half have required courses for all students and these courses average about four semester hours. Smaller schools with required communications courses seldom offer communication electives, while larger schools with extensive communication options seldom have required communications courses for all students.

Requests for classification of curricula were sent to half the schools accredited by E.C.P.D. in 1940. Twenty-nine schools sub-

mitted replies but only twenty of these had been prepared sufficiently in accordance with instructions to be used. In averaging, the individual classifications were first reduced to a percentage basis instead of semester or quarter hours. These figures were next weighted proportionally to the average number of graduates, averaged, and reduced to equivalent semester hours on the basis of a total of 75, corresponding to four semesters of eighteen hours with three semester hours for elementary E.E. in the sophomore year. This yielded the following result:

TABLE 1

Classification	Sem. Hours
1. Cultural	5.2
2. General Theoretical	7.6
3. Applied Non-E.E.	11.6
4. Business	4.9
5. Misc. Non-Electrical	0.3
6. Electric Circuits	7.9
7. Elec. and Mag. Fields	3.4
8. Electrical Machinery	14.6
9. Elec. Measurements	3.1
10. Electronics	3.7
11. Communications	10.2
12. Miscellaneous Electrical	2.5

It must be acknowledged that this system of classification is far from perfect and is based on data from too few schools. No two men might classify the same curriculum alike. However, it is believed that the above averages are sufficiently accurate for the purposes of this paper.

Comments on Non-E.E. Classifications

It must be remembered that the above analysis is based upon the two final years while most of the English, history, mathematics, physics, and other courses of the first two classifications are given in the first two years. The general theoretical classification would be slightly lower if some electives had not been assigned to it for lack of sufficient communication courses.

There naturally was some disagreement as to whether certain courses were principally general theoretical or applied non-E.E. but the distinction probably is not too important here. The major criticism of the applied courses is that few of them are nearly as useful to communication men as to the other engineers. Some schools place excessive emphasis on such courses as "Engines and Boilers" and "Fuels and Feedwaters" which are of importance to a small number of power men in steam generating stations but which merely exert a broadening influence on communication stu-

dents. Such courses might well be made electives for which communication students could substitute more physics, foreign language, or other less specialized courses.

Electric Circuits

This classification includes the "D.C. Circuits" part of the elementary course, A.C. Circuits, Transmission Lines, and Transients, when required. The fact that the last two usually are electives partially explains the low total of 7.9 semester hours. Circuit theory is so important to the communication engineer that the above four courses will be discussed separately.

D.C. Circuits or Elementary E.E.

The functions of this course seem to be (1) to provide a suitable transition between the treatment of electricity and magnetism of the Physics course and that needed for subsequent Electrical courses, (2) to show elementary applications of these fundamentals principles to *all* branches of electrical engineering so the student may appreciate the usefulness of otherwise abstract theory, and (3) to furnish sufficient practical knowledge of electric circuits to enable the student to start work in the laboratory. In addition, this course usually is relied upon for the major part of our electric and magnetic field theory. Most texts furnish an adequate introduction to fields but cannot be expected to carry this subject far enough to meet present communication needs. More will be said about this later.

The chief objection to most elementary courses seems to be their over-emphasis of power applications and their failure to show that fundamentals have equally important communication applications. Some instructors do overcome this objection by injecting personal material but, on the average, most of us follow standard texts rather closely. Therefore, it seems that the most accurate picture of this situation may be obtained from an analysis of the most widely used texts.

If this overemphasis of power does exist, it should be more apparent from an analysis of the problems than of the topic headings. Problems lend themselves most readily to statistical analysis. Furthermore, authors are apt to draw upon their own professional experience for problem material. Examples of this are familiar to all of us.

The following system has been used in analyzing the problems in the most popular texts. Problems referring to power equipment, such as motor armatures, circuit breakers, etc., or to standard power voltages or frequencies, have been placed in one group.

Problems referring to communication equipment or technique, such as telephone relays, audio amplifiers, Varley loop measurements, etc., have been grouped separately. All other problems have been classified as general, even though the magnitudes of the quantities involved show that they could not possibly illustrate communication practices. In all doubtful cases problems have been classified as communication instead of general and general instead of power, to give the text the benefit of the doubt and reduce the possibility of personal bias. "Machinery" chapters of "Circuits and Machines" texts have been omitted on the assumption that this material would be covered in a separate course, though this is not always done. The results of this classification follow:

TABLE 2

Text No.	Per Cent General	Per Cent Power	Per Cent Comm.	Pwr./Comm. Ratio
1.	66.4	31.8	1.8	17.6
2.	74.3	25.3	0.45	56.2
3.	69.1	30.2	0.67	45.3
4.	64.5	29.0	6.5	4.47
4.(-1 Chap.)	64.6	31.2	4.2	7.39
Average	68.6	29.6	1.78	16.6

Since the power to communication employment ratio is only 2.4, it seems that the power to communication problem ratio should approach this same figure if we really wish to keep our training general. However the above ratios seem to indicate that most authors have scant interest in communication. One text yielded only a single communication problem, asking for the voltage induced in a plane's trailing antenna cutting the earth's magnetic field! Only text No. 4 approaches the employment ratio and a large portion of its communication problems are contained in a single chapter which often is omitted because its material is covered in a subsequent course. Omission of this chapter raises the ratio to 7.39.

It may seem that undue importance is being attached to this neglect of communication problems. It is true that a text may be perfectly general and adequate for all students without including any communication problems, or power problems either, but this is very unlikely. The importance of the problem ratio arises largely from the fact that students spend a major portion of their preparation time working assigned problems and are apt to read the text only to the extent necessary to be able to work these problems.

It is logical that a large percentage of the problems in an elementary text should be "general," rather than of an "applied" nature, because of the fundamental nature of the course and the students' lack of engineering background. However, students seem most interested in those problems which show that apparently abstract theory ultimately may have a cash value. Use of such "applied" problems is one of the best ways of making a course appear "practical" to the students without sacrificing its true fundamental character. These "applied" problems can be, and frequently are, used to introduce material beyond the normal scope of the text and of considerable subsequent value. Students often form their first definite impression of the field covered by electrical engineering from these "applied" problems in their introductory course. Certainly we should try to make this first impression an accurate one.

A.C. Circuits

A similar analysis of the problems in modern A.C. Circuits texts is as follows:

TABLE 3

Text No.	Per Cent General	Per Cent Power	Per Cent Comm.	Pwr./Comm. Ratio
5.	36.0	61.8	2.1	29.4
6.	38.4	56.1	5.5	10.2
7.	22.9	76.0	1.1	69.0
8.	25.5	71.8	2.7	26.0
9.	38.0	49.7	12.3	4.05
10.	38.1	48.8	13.1	3.74
10.(−1 Chap.)	42.1	51.4	3.8	14.1
Average	33.8	61.6	4.6	13.4

Among A.C. texts, the power problems outweigh even the general problems. Text No. 10 seems to show the best P/C ratio but most of its communication problems are contained in a single chapter on a specialized communication topic. Many schools omit this chapter, raising the ratio from 3.74 to 14.1. This latter figure was used in obtaining the averages. Text No. 9 is a general "circuits" text with an interesting treatment of alternating currents. Its low P/C ration lacks significance because this text is not used by more than three schools. Thus, overemphasis of power applications seems to exist as badly, if not worse, among A.C. texts as among the elementary D.C. texts.

An even more serious objection to most A.C. texts is their failure to lay deeper foundations in circuit theory than have been

found necessary for power engineering. It is not so easy to assign percentages to the power and communication concepts discussed in a text. We can only suggest a few instances where many texts fall short of meeting communication needs.

Most texts introduce the vector concept of A.C. circuits by some modification of the "symbolic" method, without an adequate mathematical foundation. Students are apt to lose sight of the fact that alternating currents, themselves, are not vectors but scalar functions of time. Our vector notation actually is a consequence of an old mathematical trick for abbreviating the solution for the particular integral of linear differential equations having sine or cosine functions for their right hand members. Instead of $\sin wt$ or $\cos wt$, we use a right hand member (voltage function) of the form, $E_m e^{jwt}$, equal to the sum of a real cosine function and an imaginary sine function, and take the real part of the answer as corresponding to a cosine voltage and the imaginary part for a sine voltage. The student soon recognizes that he need only substitute jw for the differential operator, p, and a mysterious differential equation becomes merely $E = IZ$. Furthermore, he recognizes that it is just as useful to leave this answer in its complex form and use the vector symbol, E, as an abbreviation for $E_m e^{jwt}$. This method furnishes a logical and mathematically rigorous approach to our complex impedance concept, sets the stage for the introduction of transients, and develops the familiarity with exponential notation which is desirable for subsequent study of transmission lines.

It does not seem necessary to develop technique in transient analysis in an elementary A.C. course but it is vitally important that communication engineers never forget that a transient is caused whenever a voltage is changed non-recurrently. They must never lose sight of the fact that a single-frequency steady-state analysis of a communication circuit may be very misleading. By using the differential equation approach to A.C. circuits it is easy to show at the start that there always must be a "complementary function" or force-free transient solution accompanying the steady-state solution.

A study of non-sinusoidal waves is important to all electrical engineers, though for different reasons. Some texts devote considerable space to point by point methods of Fourier analysis. Such methods may be justified for determining the harmonics from an oscillogram of the exciting current of a transformer, but it is a tedious inefficient method of approximate integration which obscures the significant facts beneath pages of routine calculations. In practice, most of this work is done analytically or by means of electrical or mechanical analyzers. Anyone familiar with the basic principles of Fourier's analysis can, if the need arises, look up a

point by point method in a handbook, or even set up his own method, but a working knowledge of such methods is a poor substitute for basic theory when forced to dig through a paper involving Fourier integrals, or even the use of Fourier's series.

Students with any intellectual curiosity are apt to ask, "What is the justification for studying only the steady-state behavior of networks to single sinusoidal frequencies when all communication signals are not only non-sinusoidal but non-recurrent?" Few elementary A.C. texts make any attempt to answer this most natural question, though its answer is of the greatest importance. A simple discussion of the Fourier integral concept accompanying the treatment of non-sinusoidal waves is sufficient to inject the first ideas of bandwidth. Such a discussion is given in Everitt's "Communication Engineering" but belongs in the early chapters of all elementary A.C. texts where it cannot be dodged.

All engineers are concerned with networks which are too complicated for analysis en toto and consequently are forced to adopt methods permitting a reasonably accurate study of one small part of a network independently of its other parts. The power engineer attempts to hold a constant voltage (or constant current) so that a change of load at one point will not affect other parts of the network. In effect, the terminals for load connection are made to approximate zero (or infinite) impedance generators. The communication engineer is more interested in cascade connected networks than in the forked networks of power distribution and consequently uses vacuum tubes for isolation or matches impedances at each junction to prevent reflection of energy. All texts devote attention to "voltage regulation" but scant mention generally is made of the corresponding aspects of communication networks.

All A.C. texts devote a large amount of space to three-phase circuits. Certainly this topic requires much space and is of great importance to power engineers. However, communication engineers have little application for three-phase circuits except in the high voltage rectifiers for large radio transmitters. All students should become familiar with the basic principles of three-phase circuits but we should recognize that that "symmetrical components" is just as specialized a power topic as many we exclude from elementary courses as being specialized communication topics. Some of the basic concepts of cascade connected networks surely cannot hurt power men.

Transformers may be introduced in A.C. circuits but generally are treated most thoroughly under A.C. machinery. Communication transformers present primarily a circuit problem so it is not surprising that they received inadequate treatment in the required courses. Lack of understanding of transformer behavior is a com-

mon difficulty of young communication engineers. It is true that all transformers depend upon flux linkages between two or more windings, but beyond that the practical approach may be much different. Power engineers are interested in voltage regulation, exciting current, efficiency, and temperature rise, while communication engineers talk about frequency response, phase shift, selectivity, impedance ratio, etc. Communication transformers really present a broader subject than power transformers because their designs and applications are so varied. An ordinary radio receiver may involve an aperiodic antenna transformer, a single tuned transformer for selective R.F. coupling, and oscillator transformer, several double tuned I.F. transformers possibly having band expansion windings, a push-pull audio transformer, an output transformer, and finally a power transformer for the heaters and high voltage rectifier. All of these transformers involve somewhat different concepts and the literature on these transformers requires a broader preparation than that acquired from the study of power transformers alone.

Many other examples could be cited to show where A.C. Circuits courses are inadequate because of overemphasis of its power aspects. Of course, there are many exceptions to these criticisms, and they do not all apply to any one text or school. Some recent texts show marked improvement and numerous schools recognize these deficiencies and have been making serious efforts to correct them. However, it is believed that these still are valid criticisms of too many courses.

Transmission Lines

It is more difficult to draw conclusions concerning the treatment of transmission lines because this subject is covered in such a variety of different ways. Most A.C. texts include a chapter or two on this subject but many schools omit this and give separate courses using different texts. A few rely on a communications course for the major treatment of long line theory. Some texts are primarily concerned with power transmission and distribution, while at least one text has been written from the telephone viewpoint. Again, the chief trouble seems to be that too many of these texts and courses are not sufficiently general.

Some texts seem more concerned with developing the ability to make transmission line calculations than in promoting a clear grasp of transmission phenomena. Our complex hyperbolic functions expedite calculations but tend to obscure the basic phenomena of reflection, time delay, and attenuation. It is the alternate addition and cancellation of these direct and reflected waves which produces the queer distribution of voltage and current along long lines, so

it seems that the subject should be developed from this viewpoint *before* introducing the hyperbolic functions. The transition to the hyperbolic notation should then be easy when the student recognizes that the hyperbolic functions merely consist to two exponential terms corresponding to direct and reflected components of the wave.

Some texts start with equivalent circuit treatments of "short" and "medium" lines as an introduction to the more exact treatment of "long" lines. It is believed that this is a very inefficient process. These approximate treatments are of little value from the communication viewpoint and fail as an introduction to long lines because they do not bring out the reflection aspects of the phenomena. If we need a simplified introduction to lessen the shock of introducing hyperbolic functions of complex variables, why not start with non-dissipative lines? While such lines are of no practical interest to power engineers, they offer the simplest view of reflection phenomena and have many valuable applications in U.H.F. circuits and antenna systems. When attenuation is assumed to be negligible the direct and reflected voltages become $E_d e^{-j\beta l}$ and $E_r e^{+j\beta l}$. After developing the more essential concepts with this notation these exponential functions of imaginary variables may be combined into simple sine and cosine functions, leading to line equations which are excellent prototypes for our hyperbolic equations. After a thorough study of long lines and their equivalent circuits it should be possible to cover the short and medium line approximations in a fraction of the time otherwise required.

Field Theory

The 3.4 hours of electric and magnetic fields may not appear too low until we remember that most schools do not require any field theory other than the meagre amount contained in Physics and the elementary electrical course. The reason for this probably is that, as engineers, we have found that we could handle most practical problems from the "circuit" viewpoint, without resorting to field theory. In the communication field, however, the need for a better knowledge of field theory is becoming increasingly important.

The most obvious application of field theory is found in the study of the propagation of radio waves. Circuit theory will carry the waves up to the transmitting antenna, or from the receiving antenna to the loudspeaker, but it is the mechanism by which these waves leave the antenna and are propagated through space which is the very essence of radio communication. Many texts do a commendable job of treating propagation phenomena without mention-

ing Maxwell's equations but the authors of technical papers are not so considerate.

There are countless other communication applications of field theory, notably in electronics and in ultra-high frequency work. One of the strongest arguments for more extensive training in field theory is the need for showing the student that conventional circuit theory is merely a specialization of field theory which is valid only insofar as certain restrictions are satisfied. These restrictions are satisfied so perfectly at power frequencies that they never need be considered. However, at ultra-high frequencies all exposed parts of a circuit may radiate energy, shield compartments may behave as cavity resonators, and a host of other perplexing problems may arise. Most of these phenomena have a logical explanation in terms of field theory.

Everyone agrees upon the importance of emphasizing fundamentals rather than specialized applications. Coulomb's and Ampere's laws are perhaps our most fundamental "fundamentals" because most of our other so called "fundamentals" can be developed from these two laws by definition and straightforward mathematical reasoning. To be logical in our insistance upon fundamentals we should start with these two laws as a basis for our development of field theory, which in turn would be the basis for the introduction of the circuit concept. Such a sequence is followed in many physics courses in electricity and magnetism.

One objection to this procedure in engineering courses is the sophomore's lack of mathematical background. A more valid objection seems to be the need for introducing the circuit concept at the earliest possible date in order to get laboratory work started and lay the preparation for subsequent circuits courses. Some field theory usually is included in the elementary course but it cannot be expected to delve deeply enough into fields and still give an adequate introduction to circuits. *The only remedy seems to be a short but intensive fields course*, preferably in the junior year. Such a course should make sufficient use of vector notation that our graduates will not define vector analysis as "the process of analyzing A.C. circuits by means of vector diagrams"!

Electrical Machinery

The most strenuous objection of communication men to present electrical curricula is the disproportionate amount of time devoted to electrical machinery. All electrical students are *required* to devote an average of 14.6 semester hours to machinery, though communication men have less application for a knowledge of this subject than mechanical or civil engineers. In contrast to this,

less than four hours of Electronics is required, though electron tubes are the "machines" of the communication engineer. Communication men would benefit from a brief survey of electrical machinery, similar to that now offered non-electrical students, and it seems that power men would benefit equally from a similar survey of the communication field.

Some schools still give D.C. machinery as their sophomore introductory course, reasoning that this subject offers the best applications of D.C. circuits and magnetic fields, and is essential preparation for junior courses in A.C. machinery. D.C. machines do offer useful examples of magnetic circuits, but telegraph sounders, dynamic speaker fields, telephone relays, and filter chokes also offer good magnetic circuit applications in the communication field. Certainly we must admit that armature windings, windage losses, commutation problems, and standard performance tests are as highly specialized aspects of the power field as many communication topics now confined to technical electives or graduate courses. If electrical machinery is a truly general subject, of equal importance to all students, it seems that it should cover communication "machinery" as well as power machinery. If dynamic microphones, communication transformers, and machine switching systems are not fit topics for such a course its title should be changed to "Power Machinery" and it should no longer be considered as a truly general subject.

If most of the present machinery courses were made technical electives, sufficient time could be cleared to remedy present deficiencies in field theory, A.C. circuits, and electronics. Communication engineers need some knowledge of power machinery, but hardly fifteen semester hours of it! It is suggested that the required portion of the machinery courses be cut to four or five hours.

Electrical Measurements

The 3.1 semester hours devoted to electrical measurements seems nearly adequate and many schools are offering well balanced courses. Communication men need extensive work on impedance measurements at high frequencies with typical impedance bridge circuits, Q-meter, slotted line, twin-T null methods, etc. They need to acquire technique with the standard signal generator, cathode ray oscilloscope, harmonic analyzer, transmission measuring equipment, field strength meter, and similar communication instruments. Much of this work can be included in the communication course but there are many interesting communication measurements which can well be used to balance out a measurements course.

Electronics

Electronics still seems to consitute one of the weak links in most curricula. It is the youngest of our required electrical courses, though electron tubes have been an indispensable tool to the communication engineer for the past thirty years. It is significant that electronics did not find extensive application in the power field, except in mercury arc rectifiers, until within the past fifteen years and few schools have had required courses in Electronics for more than that length of time. Many schools feel it necessary to emphasize the industrial applications of electronics, as if it otherwise would be a communication course.

There inevitably is a close bond between electronics and communication. At many schools both courses are taught by the same man. Correspondence has indicated that some schools regard electronics as a communication course and rely upon it to inject power students with some of the communication viewpoint. Already, electronics probably is the most overburdened course in our curricula without placing this additional demand on it.

Much of the trouble students experience with Electronics may be attributed to the way we must crowd a host of new and seemingly unrelated concepts into a single three or four semester hour course. Practically all other electrical courses are based upon a very few fundamental principles which are developed in a sufficiently leisurely manner for the student to correlate them. In Electronics, we may start with an orgy of modern physics associated with electron emission and space charge flow, introduce a host of new symbols for our discussion of the characteristics of diodes, triodes, tetrodes, pentodes, heptodes, etc., rush through an inadequate treatment of the application of these tubes in amplifiers, oscillators, modulators, detectors, measuring circuits, etc., jump to photocells with new concepts of electron emission, then to cathode ray tubes and a smattering of electron optics, give passing mention to micro-ray electronics, and end by spending most of the time on the industrial applications of hot and cold cathode gas tubes! As a result, much of the time allotted to Communications must be devoted to patching up material which supposedly should be covered in Electronics.

Another factor which must be considered is that many of our concepts of electronics are changing and expanding very rapidly, just as they did during the last war, and many topics which we now pass over lightly soon will assume unusual importance. Many of our graduates now entering wartime communication work are coming in contact with electronic equipment which involve principles they have never heard of. This condition may continue after

the war unless we are prepared to re-organize our treatment of Electronics.

In view of these deficiencies, eight semester hours seems the minimum time which communication men should be required to devote to Electronics if they are to obtain a sufficient knowledge of this subject to begin to follow its progress in the literature. This time might consist of two semesters of four hours each in the junior year; the first semester being a general "three plus three" course for all students, with the usual emphasis on industrial applications, and the second semester being a "two plus six" with more extensive laboratory practice in communication electronics including U.H.F. and television applications.

Communication Courses

It might seem that the ten semester hours of communications shown in the curricula classification should be entirely adequate. Doubtless it would be if this time could be devoted entirely to communications without having to spend so much of it on elementary circuit theory, field theory, and electronics. Furthermore, it has been shown earlier that most students are not able to schedule this many hours because this was a maximum possible figure.

If ten semester hours are available, with an adequate elementary preparation, one or two semester hours might be devoted to a required course surveying the entire communication field; its basic problems, viewpoints, and opportunities. Such a course should be helpful to power men and might even serve to discourage a few less ambitious communication men! Better still, this material might be injected gradually through a number of elementary courses, along with our early picture of the power field, to avoid too early an appearance of a sharp distinction between these fields.

Unless necessitated by small enrollment, it does not seem advisable to place all communication courses on a required basis. Men seriously interested in communication usually constitute a minority and their progress may be hampered when the majority of a class have their major interests elsewhere.

The communication field is so surpsisingly broad that communication electives need not be as highly specialized and occupationally restricted as is often imagined. The field does tend to divide itself into two major classifications, wire communication and radio communication, but the distinction is not too sharp. Wire communication includes telephony, telegraphy, submarine cable work, wire picture transmission, sound engineering, geophysical surveying, etc., while the radio field includes radio telegraphy, broadcasting, television, frequency modulation, direction finding, etc. Most radio applications involve wire technique in terminal equip-

ment, while some wire systems involve radio principles. Broadcast studios are connected to their transmitters by wire lines, with amplifiers, equalizers, attenuators, etc. Carrier telegraphy and telephony involve radio techniques, while some radio circuits operate on lower frequencies than some used for carrier telephony.

Since there is such an overlap between wire and radio communication, it does not seem advisable to draw a sharp distinction between them in our communication electives, by permitting a student to specialize in radio to the exclusion of wire communication or vice versa. The student should understand the reasons for this before time for the electives.

There is little need to comment on what a communication elective should include. Given eight or ten semester hours and students with adequate preparation, any good communication teacher can organize a course capable of producing superior results. Good texts are available and better ones will doubtless appear when it becomes practical to use them. Regardless of texts, liberal use should be made of assignments from current technical literature since such literature will be the text most used subsequent to graduation.

Miscellaneous Electrical Courses

Little need be said about most of these as they represent a small portion of the total time and constitute required courses in illumination, and similar specialized subjects not fitting the previous classifications, and also seminar and the undergraduate thesis. Few schools still require theses because of administrative, space, and equipment requirements and it is questionable whether all students benefit from thesis work. However, a properly guided thesis still seems the best means of discovering and developing research ability in undergraduates.

Results of Correspondence

The additional information obtained from correspondence and discussion with educators and engineers is less susceptible to statistical analysis than the foregoing data on curricula, etc. The use of questionnaires was considered but discarded because too many land in waste baskets. Furthermore, it seemed more desirable to obtain spontaneous reactions and statements of policy which might not otherwise have been uncovered by specific questions. Personal letters were sent to the department heads or deans of those accredited schools which had not been asked for curricula classifications. These letters called attention to the tendency in former years to overstress the power aspects of electrical engineering and asked what was now being done to secure a better balance between

power and communication training. The response to these letters was better than to the requests for classifications of curricula.

As anticipated, the replies expressed many interesting and widely different viewpoints, but there also were marked similarities which permitted grouping of most replies. Almost all agreed that undergraduate training should emphasize the basic aspects of electrical engineering and avoid excessive specialization. A large number of schools recognized the tendency toward overemphasis of power and are attempting to correct this situation in different ways, while some schools seem satisfied with their electrical curricula leaning toward power specialization. Some men were encouragingly outspoken in their belief that more of the communication viewpoint was needed in our required courses. Some schools frown on electives, especially communication electives, while others offer elaborate communication options, often with little apparent attempt to balance the required courses. Several schools are abbreviating the time devoted to required machinery courses. Others are strengthening A.C. circuits or using a transition course in "Communication Circuits" to improve the preparation in circuit theory. It was surprising to learn that a number of schools regard Electronics as a communications course and rely upon it for much of the communication viewpoint. It is unfortunate that space does not permit the inclusion of numerous interesting quotations from these letters.

Opinions of Commnication Engineers

No such extensive correspondence survey has been made of the opinions of practicing communication engineers but opinions have been obtained whenever possible through conversation. Most of these opinions have been embodied in the previous discussion of courses but a few additional items need comment. A large percentage of the men doing communication research and development have been trained as physicists and many excellent engineers still are not college graduates. It is certain that electrical engineering training, as we have thought of it in the past, is not essential to success in communication research. Some even feel it is not desirable. A physicist entering communication may be slightly handicapped at first by lack of specialized technical knowledge but his superior grasp of fundamentals usually pays dividends in a few years.

Most men agree that communication training can and should be improved. Some favor separate curricula in communication engineering with greater specialization, while others favor more thorough basic training with less specialization, particularly in power applications. Practically all communication engineers agree

that men trained for four years primarily for power engineering cannot be converted into good communication engineers merely by exposure to a course in "Ultra-High Frequency Technique."

The statement that "specialized communication training should be confined to graduate courses" strikes a discordant note with many communication engineers who have taken advanced degrees. They agree with this statement in principle, but not in practice. It too often develops that most of the first graduate years must be devoted to broadening the foundations in circuit theory, field theory, and electronics, with scant time left for truly "specialized" topics. Even more advanced courses often devote excessive time to reviewing Fourier's Series and similar topics. A course called "Radio Receiver Design" may degenerate into an extended treatment of tuned coupled circuit theory, with slight time left for consideration of converter efficiency, diode detection, A.V.C. systems and other specialized aspects of the subject which the student hoped to master. After such experiences, a man cannot be blamed for wishing that he might have swapped some of his required undergraduate training in armature winding and flue gas analysis for sufficient basic training to permit graduate specialization.

Most communication employers agree that a broad knowledge of basic theory is more desirable in a young engineer than an extensive knowledge of specific communication practices. The telephone companies generally do not expect, nor desire, to hire graduates trained in the design, selection, installation, and maintenance of telephone equipment. They prefer men with sound basic training and find that such men can learn specific practices more quickly and thoroughly on the job than in college. Power employers may be different, but this is questionable.

How Much Power Specialization Is Justified?

The principal argument always advanced in support of strong emphasis on power engineering in required courses is the greater probability of a student finding employment in the power field. This argument had great justification back in the days when the telephone industry was almost the sole employer of communication men and hired less than ten per cent of our graduates. Somewhat greater attention to power than to communication still is justified because there were 2.4 times as many graduates employed in the power field as in the communication field, just before the present war. However, communication has become such a broad field, with such diversified employment opportunities, that a man no longer need be forced into power employment just because he is not acceptable to the telephone company. Furthermore, if we agree that a sound basic background is of greater value to a young com-

munication engineer than a knowledge of specialized communication practices, is it likely that communication training would seriously handicap a man entering the power field? Is not the study of the behavior of networks to non-recurrent, non-sinusoidal waves more general than a study of their behavior at one constant frequency?

A common justification for the large percentage of power problems in texts is that such problems offer the most common and familiar applications. This, also, might have been true twenty years ago but today more of our sophomores have a knowledge of amateur radio than of D.C. machinery. The application of Ohm's law to the voltage divider in a receiver would sound much more familiar to most students than its application to a field rheostat. Is it not possible that these power problems are more familiar to us than the students?

Some schools in certain sections of the country do have greater difficulty placing their graduates in communication employment. Such schools probably are justified in neglecting communication for greater power specialization, but this fact should be brought to the prospective student's attention. If a prospective student has decided that he would like to "study radio," regardless of his reasons or aptitudes, it does not seem fair to lead him to believe he will receive the training he expects when we intend to train him for power employment.

Conclusions

It is believed that sufficient data have been presented, from analysis of employment, curricula, textbook problems, and correspondence, to prove that there still exists a strong tendency toward overemphasis of the power aspects of Electrical Engineering and that a broadening and strengthening of our elementary electrical courses, at the expense of some power specialization, would improve our graduate's prospects for success in the communication field. Many schools appear to be moving in this direction, and this movement probably will be accelerated by our wartime experiences with communicating training.

The communication deficiencies of elementary texts are being overcome in some of the newer editions and instructors are correcting these deficiencies by lecture notes, additional problems, and other means. Better texts will doubtless appear as the need for them becomes more generally recognized.

Separate undergraduate curricula in Communication Engineering do not appear necessary nor desirable if the present tendency toward broadening of the elementary courses and reduction of required power specialization continues.

The best yardstick for measuring the effectiveness of communication training appears to be a comparison of our graduate's ability to digest current *technical* literature in the communication and power fields. Any means of reducing the gap between the level of an engineer's training and the level of the technical literature of his profession will improve his prospects for professional development.

E.S.M.W.T. courses and similar accelerated communication programs are doing much to meet our immediate shortage of communication men, but must be regarded as emergency measures. The recommendations contained in this paper are more of a long-term nature, for the benefit of our present Juniors and students in the reconstruction period to come.

Appendix A

INSTRUCTIONS ACCOMPANYING QUESTIONNAIRES

General Information

The following classifications represent an attempt to break down the final two years of the electrical curricula according to basic subject matter, rather than actual course titles. Assume that the student chooses all possible technical options in the communication field and all possible non-electrical options in the General Theoretical classification (Math., etc.). For five years curricula leading to the Master's degree, neglect the final year. Five year curricula leading to the B.S. degree, such as coöperative courses, should be treated on the basis of equivalent four year curricula.

Course Classifications

1. *Cultural Courses*. This classification should include all junior and senior non-technical courses given primarily to improve the students' cultural background. Examples of such courses would be English, history, religion, etc.

2. *General Theoretical courses* should include mathematics, physics (other than electrical measurements), thermodynamics (other than that devoted exclusively to steam), mechanics, fluid mechanics, etc.

3. *Applied Non-Electrical Courses* are considered as those which are applicable primarily to a specific field of non-electrical engineering. Examples would include heat engines, "wet" hydraulics, M.E. lab., mechanisms, strength of materials, etc.

4. *Business Courses* would include such topics as economics, business administration contracts and specifications, cost accounting, business law, etc.

5. *Miscellaneous Non-Electrical Courses* would include physical education, military training, shop practice, and other courses which do not fit the above classifications.

6. *Electric Circuits* should include D.C. circuits, even though taught in the sophomore year. It should also include the "circuits" portions of transmission lines and any similar courses, but should exclude those phases of electric circuit theory taught in communication courses and applicable primarily to communication work.

7. *Electric and Magnetic Fields* may include this phase of the elementary electrical course, even though taught in the sophomore year. It may also include parts of subsequent courses, such as design, but should not include applications of field theory to electrical machinery (*i.e.*, magnetic circuits of machines).

8. *Electrical Machinery.* D.C. and A.C. machinery, including transformers. May also include part of design or problem course dealing with machinery.

9. *Electrical Measurements* may include parts of other courses but should exclude distinctly communication measurements (radio frequency, etc.).

10. *Electronics* may include those portions of subsequent communication courses which deal with the fundamentals of electronics, rather than distinctly communication applications.

11. *Communication Courses* include communication circuit theory, telephony, radio, etc., as well as any appropriate portions of prior courses.

12. *Miscellaneous Electrical Courses* should include those electrical courses not fitting the above classifications. For example, illumination, thesis, seminar, etc.

Other Information

13. *Average Size of Graduating Class* during the past five years. This information will be used in obtaining a weighted average of the curricula.

14. *Employment.* This information is to determine the relative percentage of graduates entering the communication and power branches of electrical engineering, as well as the percentage of those who fail to follow their profession. All occupations based primarily upon communication technique, such as geophysics, sound recording, etc., should be classed as communication. Other work, involving commercial power frequencies and power technique should be classed as power. It should not be necessary to check personnel records in answering this question as an accuracy of five or ten per cent will be adequate.

ENGINEERING ECONOMY NOTES

Engineering economy is that phase of engineering which pertains to the specifically advantageous use of dollars and cents in engineering works.

By EDMUND D. AYRES

Acting Editor, The Ohio State University

The Curious Plight of Engineering Economy

Engineering economy is in a curious plight. First it was definition—after the clarifying struggle staged in the Engineering Economy Page a few years ago, some of us feel that we can pretty well defend the term engineering economy against any and all competing names for this distinct corner of the engineering field. But now it is agreement upon what should be considered the best in thought and practice in the field of engineering economy that is needed to rescue our subject from confusion—a confusion that evidently is taken as a normal background. Worse than that, it is evidently a confusion which is neither perceived nor acknowledged by most of us. We take our engineering economy like we do our politics and religion—somehow our private brand satisfies.

I was quite pleased with my private brand until my experience with the subject unfolded. It is not that we are all steeped in error although occasionally there is evidence of a little of that. Let us take just one little tiny corner of our field to demonstrate a matter that is so commonplace that we have just accepted it without worrying at all about what our colleagues and engineers in practice are doing with it. The difficulties to be pointed out appear in the non-controversial part of our work. These same difficulties together with others pervade much of the entire field we cultivate every time we teach a class or work out a problem in economic selection.

Let us consider a problem with revenue and expense data available and the simple requirement for an arithmetical answer. Not so long ago a close friend of mine, a president of a prominent engineering society and a recognized consulting engineer of wide experience, stumped the nation to bring to his colleagues a bit of economic gospel couched in terms of a profit on the employment of an engineering device expressed as a per cent yield over and above a 6 per cent satisfaction interest on the investment involved. He presented his thesis without even drawing one's attention to the

method—evidently he took it for granted that return on investment is always expressed so—he seemed violently prejudiced against any compound interest being involved. There are many others opposed to compound interest, that is to sinking fund depreciation calculations for studies made for business units practicing straight line or retirement principles in their accounting. Yet some of our best textbooks condemn roundly the practice of computing return on a fixed investment when straight line depreciation is involved. An average investment or interest method is recommended by one of our engineering economy authorities when straight line depreciation is used. Practically all of our textbook writers insist upon compound interest calculations—either sinking fund depreciation at a nominal rate of interest or sinking fund depreciation at a rate equal to the rate of return. This makes about five methods for the solution of the simplest problem with which we are confronted. It is not that all are not correct—but nowhere do we find much guidance as to the best thought as to when each method is applicable—they all give different answers and those that propose these methods seem to cry for universal application of their favorite to the exclusion of the others. This state of affairs exists in a relatively non-controversial area of our work—even more confusing situations occur in some other parts of our field—for instance, what constitutes a satisfactory investment in a device to be used by a regulated industry like a public utility?

Space does not permit a very broad treatment of the general picture suggested by the above. Nevertheless it is not so much the strange situations which are part and parcel of our theory and practice—it is the curious confidence we all have that what we teach and do in practice is beyond reproach—why should we not be trying zealously to bring order out of such confusion—it seems to me that engineering economy is in a curious plight. Plans for coöperative struggle to rescue it should be one of the prime duties of the post war period.

THE T-SQUARE PAGE

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Devoted to the Interests of Engineering Drawing

William E. Street, *Editor*

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DRAWING DIVISION PROGRAM OF S. P. E. E., 51ST ANNUAL MEETING

Friday, June 18th

7:00 P.M. Drawing Division Dinner—Speaker to be announced.

Saturday, June 19th

12:30 P.M. Luncheon—Business meeting.

2:00 P.M.
1. Teaching Production Illustration, by C. H. Springer, University of Illinois.
2. A New Exact Method of Axonometric Production, by R. P. Hoelscher, University of Illinois.
3. Report of Committee on Graphic Talents, by Clair V. Mann, Missouri School of Mines and Metallurgy.
4. Other Committee Reports.

Visual education affords an excellent opportunity for instruction in the teaching of engineering drawing, particularly in the use of instruments, testing of drawing instruments, pointing out the peculiar characteristics of engineering letters; and the combining of letters into words, shop processes, etc. There are a number of advantages in using moving pictures: (1) They give the students an insight into industrial practices in a few minutes which would take several hours to get if an inspection trip was conducted, thereby saving time that the students can profitably use in the crowded curricula of today; (2) a subject like the use of instruments can be covered much more thoroughly in less time with a good moving picture than by demonstration by the instructor; (3) seeing a picture is a very effective means of demonstrating correct use of instruments that is difficult to demonstrate on the blackboard and if the students gather around the instructor at a desk many of them can not see the demonstration well, and lose interest.

Although visual education definitely has its place in the teaching of engineering drawing the lecture-conference-demonstration period is very important and an effective means of explaining the theory of drawing to students. Since engineering drawing is a basic subject for engineers, sufficient time should be allowed for this important fundamental subject. It requires one hour of lecture and six hours of practice per week for two semesters to cover the material that industry requires the engineering graduate to know in this mechanical age. After completing the two semesters of freshman engineering drawing the student should take a semester of engineering descriptive gometry as applied to industry and a semester of machine drawing to be thoroughly grounded in the fundamentals of drawing. Much lettering should be included in all the above courses.

SECTIONS AND BRANCHES

The officers of the **Colorado School of Mines Branch** are as follows: R. A. Baxter, *Chairman;* W. M. Richtmann, *Vice Chairman;* E. G. Fisher, *Secretary.*

The officers of the **Illinois-Indiana Section** are: P. E. Mohn, *Chairman,* University of Illinois; W. M. Lansford, *Secretary-Treasurer,* University of Illinois; C. Wischmeyer, Rose Polytechnic Institute; J. C. Peebles, Illinois Institute of Technology; W. W. Turner, University of Notre Dame; C. L. Lovell, Purdue University; R. G. Bigelow, Northwestern University; G. A. Maney, Northwestern University; J. C. Peebles, *Member of Nominating Committee,* Illinois Institute of Technology.

NEW YORK PROVIDES FOR ENGINEERS-IN-TRAINING

One hurdle for engineers seeking licenses to practice in New York State has been lowered through a change in the regulations of the Commissioner of Education which permit qualified graduates of registered colleges of engineering to take their examination in two sections, the first, dealing with theory as soon as they are graduated; the second, dealing with practice, after completion of four years of satisfactory experience. Heretofore, applicants for engineering licenses were permitted to take both parts of the examination only after completing the four-year minimum experience requirement.

The amendments to the Commissioner's regulations establish preliminary examinations for engineers-in-training. These are open to graduates of registered colleges of engineering upon submitting evidence that they meet the requirements as to age, citizenship, secondary education and endorsement. There are two parts to this section of the examinations.

The final examination is available to applicants who have demonstrated sufficient experience in their own particular lines of engineering, through at least four years of practice.

This change was made after a thorough study by the State Education Department of requests by professional groups to permit the young engineering graduate to try the preliminary examinations immediately after completing his college course, while his knowledge of theory was still fresh. The change in the examinations

was approved by the New York State Board of Examiners of Professional Engineers and Land Surveyors, and the Board of Regents.

COLLEGE NOTES

James R. Killian, Jr., has been appointed executive vice-president of the **Massachusetts Institute of Technology**. Mr. Killian has been executive assistant to the president since January, 1939, and takes over his new post on July 1st. Before joining the staff of the president in 1939, Mr. Killian had been associated for thirteen years with the publication of the *Technology Review*, of which he became editor in 1930.

NEW MEMBERS

ANDREWS, ANDREW I., Professor and Head, Dept. of Ceramic Engineering, University of Illinois, Urbana, Ill. M. L. Enger, R. P. Hoelscher.

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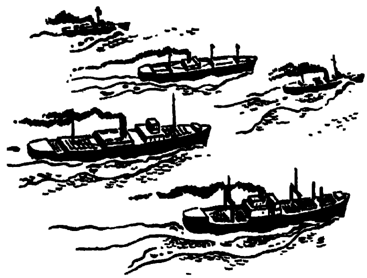

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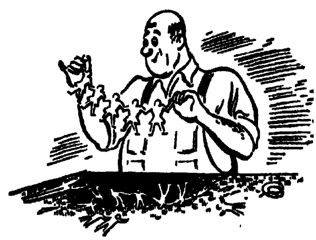

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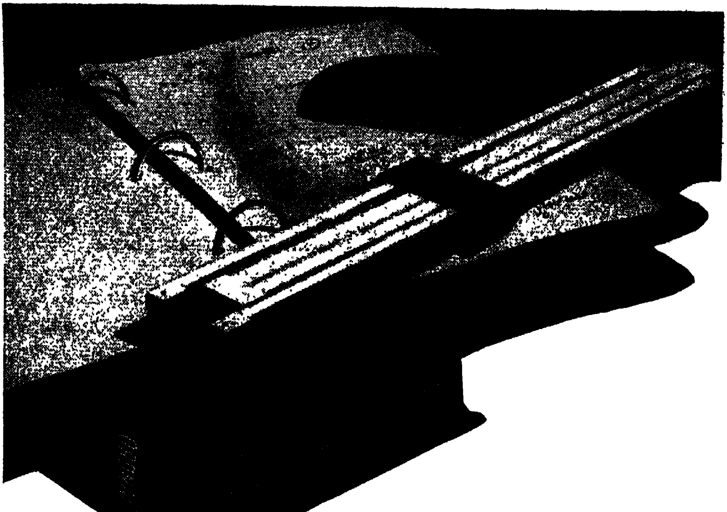

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